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Rubidium in Lead and Barium Glasses

by H. E. Simpson

STATE UNIVERSITY OF NEW YORK
COLLEGE OF CERAMICS
ALFRED UNIVERSITY, ALFRED, N. Y.

THE GLASS INDUSTRY is constantly seeking materials which will enhance glass products by providing new and unusual properties. While the fluxing power of alkali carbonates, such as sodium and potassium carbonate, has been known for many years, additional compounds are now available for evaluation: rubidium and cesium salts.

Technical grade* rubidium and cesium carbonates are now obtainable at a price which is only a fraction of that charged formerly.

The availability of these fundamental materials in high purity provides the glass and ceramic industries with the opportunity of creating new glasses with possible unusual properties.

In general, rubidium compounds resemble those of the other alkali metals; however, significant differences are evident because of variations in ionic dimensions, different heats of hydration, and the ease with which the outer electron is lost. The reactivity and the properties of specific alkali metal compounds depend to a large extent on the properties of the metal or cation involved. Table I shows certain of the properties of the alkali metals and is presented here for consideration in specific applications.

Table III lists some of the properties of rubidium compounds. A similar series of cesium compounds is also available for commercial evaluation.

Although cesium has properties similar to the other alkali metals, it is the most reactive member of the group. Its greater atomic weight and radius make it markedly different from the other alkali metals, as evidenced by comparing the solubilities of various salts in water and comparing the ionization potentials of the gaseous atoms.

Table IV is indicative of some of the properties of the cesium compounds.

The action of these higher atomic weight alkali metals in glasses is not specifically known. It is quite probable, however, that definite effects will be noticed with such properties as rate of melting, softening point, viscosity, workability, annealing, density, and refractivity. The problem of durability may also be influenced.

Colors and electrical properties are also known to be profoundly influenced by size and mobility of the alkali cation. One would expect rubidium to react similarly to potassium because of its ionic radius and mobility. Cesium, on the other hand, is very reactive and may show other properties and characteristics. The possible applications of these interesting new materials are varied in affecting crystal growth, crystal formation, or in modifying glass properties.

More recently work with lithium as a fluxing alkali has received the attention of a number of investigators.[1] However, no specific knowledge has been available covering the effects of rubidium and cesium.

* According to a recent annoncement by the American Potash and Chemical Corporation.

[1] H. E. Simpson, "Lithium Development and Expansion," THE GLASS INDUSTRY 36 (1) 17-22, 46-47 (1955).

Table I

PROPERTIES OF ALKALI METALS*

Property	Lithium	Sodium	Potassium	Rubidium	Cesium
Atomic Weight	6.940	22.997	39.096	85.48	132.91
Density (20°C.)	0.534	0.97	0.86	1.53	1.90
Melting Points, °C.	186	97.5	63.7	38.5	28.5
Important Spectral Line	6707.8A	5890A	7664.9A	7800.2A	8521.1A
Ionization Potential of Gaseous Atoms, Volts	5.37	5.12	4.32	4.16	3.87
Volume of ions x 10^{23} cc.	0.14	0.37	0.99	1.36	1.95

* "The Alkali Metals," Comprehensive Inorganic Chemistry, Vol. VI, J. F. Suttle, D. Van Nostrand Company, Inc. (1957).

The majority of the ceramic oxides produce ions which are considered, for the most part, as spheres in which the ionic radius has a real meaning. Zachariasen has given a comparison of these ionic radii as shown in the following table.

Table II

IONIC RADII OF ZACHARIASEN

(In Angstrom Units)

Li^+	0.68	Be^{+2}	0.39	B^{+3}	0.24	O^{-2}	1.40
Na^+	0.98	Mg^{+2}	0.71	Al^{+3}	0.55	F^{-1}	1.33
K^+	1.33	Ca^{+2}	0.98	Si^{+4}	0.44		
Rb^+	1.48	Sr^{+2}	1.15	P^{+5}	0.34		
Ca^+	1.67	Ba^{+2}	1.31				

It is to be noted that rubidium (Rb^+) ion possesses one of the largest ionic radii of the Group I Alkali elements. Because of its apparent refractoriness and high viscosity, it was considered logical to study first glasses involving Rb_2O-PbO-SiO_2. It was believed that lead oxide (PbO) would probably flux the more refractory rubidium ion and, at the same time, reduce the excessive viscosity. Another possible advantage of rubidium and lead was that these glasses might possess exceptionally good brilliance. The first study with rubidium was, therefore, made in the Rb_2O-PbO-SiO_2 system.

Barium glasses are also known to be quite similar to corresponding lead glasses. Some of the desirable properties are high brilliance, high density, and, according to some investigators, better durability than lead. Barium glasses, on the other hand, are known to offer difficulties in melting; that is, they tend to be refractory or difficult to fuse. Such glasses are also liable to be cordy, difficult to fine, and are liable to corrode or attack

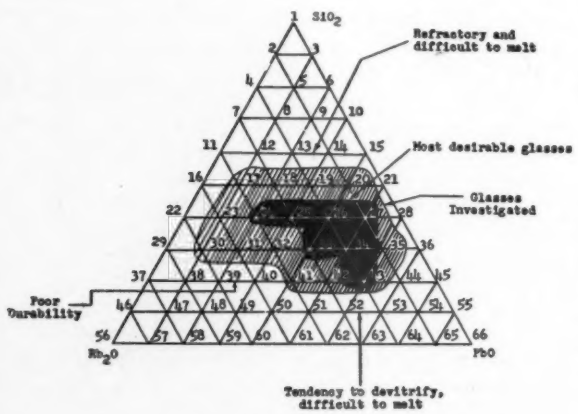

Fig. 1. Lead glasses studied.

refractories. As a rule, if the BaO content exceeds approximately 30 per cent such glasses are liable to devitrify. In general, barium glasses are similar to lead glasses with the exception that the action of the Ba^{2+} is not as effective and strong as the Pb^{2+}.

Barium glasses, nevertheless, possess many desirable properties, and it would be quite advantageous to be able to provide glasses with high barium content. For this reason, a study of the system RB_2O-BaO-SiO_2 was considered very much worthwhile. In addition, it is logical to study this system as a supplement to the study of the Rb_2O-PbO-SiO_2 system mentioned above.

Experimental Glasses

A. Raw Materials

All the raw materials used were c.p. glass grade materials of high purity, comparable to those used in the glass industry.

Commercial lead silicate (85 per cent PbO, 15 per cent SiO_2) was used to supply the needed amount of PbO.

The rubidium carbonate, obtained from American Potash and Chemical Corporation, had the following analysis:

Rb_2CO_3	96.7 per cent
$CsHCO_3$	.14 per cent
$KHCO_3$	2.53 per cent
Na_2CO_3	.32 per cent
SiO_2	.27 per cent

The barium carbonate, known as "TV Grade" because of its use for television tube glasses, was obtained from the Barium Reduction Company, South Charleston, West Virginia. It was of high purity and rather coarsely ground in order not to be dusty in handling for glass batching. The glass sand, typical of that used in the glass industry, was obtained from the Pennsylvania Pulverizing Company, Lewistown, Pennsylvania. It was approximately 99.9 per cent SiO_2.

B. Melting

All glasses were fused in high-quality porcelain crucibles which had been previously cast from a mixture of feldspar-clay-flint and well matured by firing up to 1100°C. The melting temperatures varied from 1350°C. (2462°F.) to 1450°C. (2462°F.-2642°F.) for the lead glasses and from 1450°C. (2642°F.) to 1525°C. (2642°F.-2775°F.) for the barium glasses. Sufficient time was permitted to obtain a quiet fusion wherever possible. On completion of melting, the glasses were poured onto a previously heated iron plate and cast into buttons 1

Table III

PROPERTIES OF RUBIDIUM COMPOUNDS

Property or Value	Rubidium Compound			
	Carbonate	Sulphate	Chloride	Fluoride
Molecular Weight	230.97	267.02	120.94	104.48
Melting Point, °C.*	835	1074	717	775
Heat of Fusion, Kcal/mole*	.....	.....	4.40	4.13
Heat of Formation	−269.6 (c)	−340.50 (c)	−102.91 (c)	−131.28 (c)
Kcal/mole* at 25°C.	−278.0 (aq)	−334.7 (aq)	− 98.9 (aq)	−137.6 (aq)
Specific Heat, cal/deg mole*	28.4	.....	12.3	12.2
Boiling Point at 760 mm Hg*	decomposes	.....	1408°C.	1381°C.
Heat of Vaporization, Kcal/mole*	.....	.....	36.92	39.51
Solubility in Water†				
Grams/100 gms H_2O Ca 25°C.	222.7	48.1	91.2	130.6

* Selected Values of Chemical Thermodynamic Properties, NBS Circular 500, (1952).
† The Chemical Elements and Their Compounds, Vol. I, N. V. Sidgwick, Oxford University Press (1950).

Table IV

PROPERTIES OF CESIUM COMPOUNDS

Property or Value	Cesium Compound			
	Carbonate	Sulphate	Chloride	Fluoride
Molecular Weight	325.82	361.88	168.37	151.91
Melting Point, °C.*	decomposes	1019	645	682
Heat of Fusion, Kcal/mole*	.....	.....	3.60	2.45
Heat of Formation	−267.4 (c)	−339.38 (c)	−103.5 (c)	−126.9 (c)
Kcal/mole* at 25°C.	−278.6 (aq)	−335.3 (aq)	− 99.2 (aq)	−135.9 (aq)
Solubility in Water†				
Grams/100 gms H_2O Ca 25°C.	261.5	179.1	185.8	366.5

* Selected Values of Chemical Thermodynamic Properties, NBS Circular 500, (1952).
† The Chemical Elements and Their Compounds, Vol. I, N. V. Sidgwick, Oxford University Press (1950).

o 2 inches in diameter and about ¼ inch thick. After asting, each sample was immediately put into an annealng oven and slowly cooled from 1000°F. in order to reieve the strains. The melting characteristics, ease of pouring, viscosity, color, and general working characteristics of the glass were observed. Any corrosion of the refractory was also noted.

C. *Lead Glasses Studied*

The preceding triaxial diagram (Fig. 1) indicates the various members possible when plotted at 10 per cent intervals. The areas studied are indicated by cross-hatching.

D. *Barium Glasses Studied*

The following triaxial diagram (Fig. 2) indicates the various members possible when plotted at 10 per cent intervals. The areas studied are indicated by cross-hatching.

Physical Properties

In order to evaluate these glasses more thoroughly, the physical properties of density, refractive index, Littleton's softening point, and coefficient of expansion were determined for the more promising glasses. In order that samples may be properly identified, reference should be made to the triaxials (Fig. 1 and Fig. 2) as well as Table V and Table VI describing the raw batch and composition of the various members.

[2] G. W. Morey, "The Properties of Glass," Reinhold Publishing Corporation, New York (1938), 379-381.

A. *Density*[2]

Density determinations were made by a modification of the Archimedes or displacement method. The sample was weighed both in air and immersed in a liquid of known density. In this instance, the immersion liquid was water. The displacement method is commonly used in the glass industry when glasses of reasonable good durability (poor solubility in water) are studied. A fragment or lump of the glass was suspended by means of a platinum wire or sling from the beam of a balance; the weight in air and pure water was determined; and the loss of weight in grams expressed the volume of the glass in cubic centimeters. The density was calculated from:

$$D = \frac{Wa}{Wa - W_w}$$

Where Wa = weight of glass in air
W_w = weight of glass in water

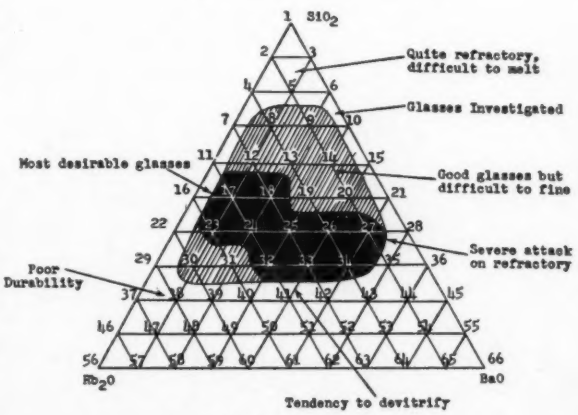

Fig. 2. Barium glasses studied.

B. Index of Refraction[3]

The index of refraction was determined by the well-known "Becke Line Method." A portion of each individual glass sample was ground in a mortar and pestle and then screened through a 100-mesh screen. By immersion of the powdered sample in oils of known indices, the index of refraction of the unknown glass sample was determined. As the eye-piece of the microscope is moved upward, the Becke Line (well-defined outline of each glass grain) moves from the low to high index. By means of a series of such determinations with immersion oils of varying indices, it is possible to ascertain the range of index of each glass. This method is capable of very high precision, especially where immersion oils of accurate indices are available.

C. Littleton's Softening Point[4]

The softening point of a glass as defined by Littleton is: "A temperature at which a filament of glass of specified diameter and length, heated at a given rate, elongates under its own weight 1 millimeter per minute." The viscosity at the Littleton softening point as stated by Lillie is 4.5×10^7 poises, or $\log \eta = 7.65$. The softening point of each glass was determined by the Littleton fiber-elongation method. Generally speaking, the softening point of a glass runs about 200°C. higher than its annealing temperature. The range for commercial glasses varies from approximately 500°C. to 800°C.

[3] H. Insley, and V. D. Frechette, *Microscopy of Ceramics and Cements*, Academic Press Inc., New York (1955).
[4] J. T. Littleton, J. Am. Cer. Soc. *10*, 259-263 (1927).

Table V

RAW BATCH AND PER CENT COMPOSITION OF LEAD GLASSES STUDIED

Point #	Raw Batch by Wt. (Grams)			Composition of Glasses					
		Lead		Weight Per Cent			Mole Per Cent		
Member	Rb_2CO_3	Silicate	Sand	Rb_2O	PbO	Si.O	Rb_2O	PbO	SiO_2
17	49.2	11.8	48.2	40.0	10.0	50.0	19.6	4.1	76.3
18	36.9	23.5	46.5	30.0	20.0	50.0	14.8	8.2	77.0
19	24.7	35.3	45.7	20.0	30.0	50.0	10.0	12.5	77.5
20	12.4	47.0	42.9	10.0	40.0	50.0	5.0	16.8	78.2
23	61.5	11.8	38.2	50.0	10.0	40.0	27.3	4.6	68.1
24	49.2	23.5	36.5	40.0	20.0	40.0	22.0	9.3	68.7
25	36.9	35.3	34.7	30.0	30.0	40.0	16.6	14.0	69.4
26	24.7	47.0	33.0	20.0	40.0	40.0	11.2	18.8	70.0
27	12.4	58.8	31.2	10.0	50.0	40.0	5.6	23.7	70.7
30	73.8	11.8	28.2	60.0	10.0	30.0	37.1	5.2	57.7
31	61.5	23.5	26.5	50.0	20.0	30.0	31.2	10.5	58.3
32	49.2	35.3	24.7	40.0	30.0	30.0	25.2	15.9	58.9
33	36.9	47.0	23.0	30.0	40.0	30.0	19.1	21.3	59.6
34	24.7	58.8	21.2	20.0	50.0	30.0	12.8	27.0	60.2
35	12.4	70.5	19.5	10.0	60.0	30.0	6.5	32.7	60.8
41	49.4	47.04	13.0	40.0	40.0	20.0	29.5	24.7	45.8
42	37.05	58.8	11.2	30.0	50.0	20.0	22.3	31.3	46.5
43	24.7	70.5	9.5	20.0	60.0	20.0	15.1	37.9	47.0

RESULTS OF STUDY

Point #	Glass Rating	Description of Glass
17	Good Glass	Difficult to melt, quite viscous and contained some seeds. Higher melting temperature needed.
18	Good Glass	Difficult to melt, contained seeds, and quite viscous. Higher melting temperature needed.
19	Fair Glass	Poured easily but set quickly on cooling.
20	Fair Glass	Quite fluid but difficult to melt.
23	Good Glass	Quite viscous and showed poor durability on ageing.
24	Excellent Glass	Somewhat stiff and viscous when poured. Good durability.
25	Good Glass	Poured easily, not too viscous, slight yellow color. Good durability.
26	Excellent Glass	Poured easily, not too viscous, good color and durability.
27	Fair Glass	Poured easily, slight yellow color.
30	Good Glass	Quite viscous but poured fairly well. Poor durability on ageing.
31	Good Glass	Fairly viscous, poured with difficulty, poor durability on ageing.
32	Good Glass	Fairly viscous, poured well but questionable durability on ageing.
33	Very Good Glass	Poured easily, slight yellow color, good brilliance, and satisfactory durability.
34	Excellent Glass	Poured easily, slight yellow color, excellent brilliance and satisfactory durability.
35	Fair Glass	Poured easily, slight yellow color. Some melting difficulties.
41	Excellent Glass	Poured easily, very fluid, but poor durability.
42	Excellent Glass	Poured easily, very fluid, questionable durability.
43	Excellent Glass	Poured easily, very fluid, satisfactory durability.

D. Coefficient of Expansion by Dial Gage

In common with most other substances, glasses expand when heated and contract when cooled. The magnitude of this change, which varies according to the composition of the glass, is expressed numerically as the coefficient of expansion. The linear coefficient, α, (alpha) refers to the fraction of its length by which a piece of glass expands for a rise in temperature of 1°C. Because the expansion is not uniform over all temperature ranges, it is desirable when calculating the coefficient to specify the interval (a common temperature range is from 0° to 300°C.) over which the expansion is measured.

The change in dimensions of a sample rod of glass 4 to 5 inches long is measured by means of a dial gage, and the linear coefficient of thermal expansion was then calculated by the following formula:

$$\alpha = \frac{\triangle 1}{L_{\theta}} + 5.0 \times 10^{-7}$$

In this formula, $\triangle 1$ is the difference in dial readings or apparent expansion from room temperature to 300°C. L is the original length of the specimen. Θ is the rise in temperature, degrees C.; and 5.0×10^{-7} is the coefficient for fused silica glass.

E. Durability Tests

No durability tests as such were carried out with these glasses; that is, no powder tests, autoclave or so-called solubility tests were made. The appearance of "bloom" or surface chalking was carefully observed and when such conditions were found the facts were recorded

Table VI

RAW BATCH AND PER CENT COMPOSITION OF BARIUM GLASSES STUDIED

Point #	Raw Batch by Wt. (Grams)			Composition of Oxide					
					Weight Per Cent			Mole Per Cent	
Member	Rb_2CO_3	$BaCO_3$	SiO_2	Rb_2O	BaO	SiO_2	Rb_2O	BaO	SiO_2
8	24.7	12.9	70.0	20.0	10.0	70.0	8.0	4.9	87.1
9	12.4	25.8	70.0	10.0	20.0	70.0	4.0	9.7	86.3
12	18.5	6.4	30.0	30.0	10.0	60.0	13.1	5.3	81.6
13	24.7	25.8	60.0	20.0	20.0	60.0	8.6	10.6	80.8
14	12.4	38.6	60.0	10.0	30.0	60.0	4.2	15.7	80.1
17	49.4	12.9	50.0	40.0	10.0	50.0	19.3	5.8	74.9
18	37.1	25.8	50.0	30.0	20.0	50.0	14.2	11.7	74.1
19	24.7	38.6	50.0	20.0	30.0	50.0	9.4	17.3	73.3
20	12.4	51.5	50.0	10.0	40.0	50.0	4.6	22.8	72.6
23	61.7	12.9	40.0	50.0	10.0	40.0	26.7	6.5	66.8
24	49.4	25.8	40.0	40.0	20.0	40.0	21.2	12.9	65.9
25	37.1	38.6	40.0	30.0	30.0	40.0	15.6	19.2	65.2
26	24.7	51.5	40.0	20.0	40.0	40.0	10.3	25.3	64.4
27	12.4	64.0	40.0	10.0	50.0	40.0	5.1	31.2	63.7
30	73.8	12.9	30.0	60.0	10.0	30.0	36.3	7.3	56.4
31	61.5	25.8	30.0	50.0	20.0	30.0	29.8	14.6	55.6
32	49.4	38.6	30.0	40.0	30.0	30.0	23.6	21.5	54.9
33	37.1	51.5	30.0	30.0	40.0	30.0	17.4	28.3	54.3
34	24.7	64.0	30.0	20.0	50.0	30.0	11.5	35.0	53.5
35	12.4	76.8	30.0	10.0	60.0	30.0	5.6	41.5	52.9
42	61.8	38.6	20.0	50.0	30.0	20.0	33.6	24.6	41.8

RESULTS OF STUDY

Point #	Glass Rating	Description of Glass	Point #	Glass Rating	Description of Glass
8	Good Glass	Clear glass, fairly viscous and difficult to fine.	24	Excellent Glass	Orange cast, poured and fined easily.
9	Good Glass	Clear glass, fairly viscous and difficult to fine.	25	Excellent Glass	Clear glass, poured and fined easily.
12	Good Glass	Clear glass, poured well, some seeds.	26	Excellent Glass	Clear glass, poured and fined easily.
13	Good Glass	Clear glass, slight yellow tint, poured well, some seeds.	27	Very Good Glass	Clear glass, poured and fined well.
14	Good Glass	Clear glass, quite viscous, difficult to fine.	30	Good Glass	Melted and poured easily, but poor durability on ageing.
17	Excellent Glass	Clear glass, fairly fluid, fined well.	31	Fair Glass	Opalescent and poor durability.
18	Excellent Glass	Clear glass with yellow tint, a little viscous, fined well.	32	Excellent Glass	Yellow cast, melted and poured well. Durability satisfactory.
19	Good Glass	Yellow cast, quite viscous, difficult to fine.	33	Excellent Glass	Clear glass, melted and fined well, good durability.
20	Good Glass	Yellow cast, fairly viscous, some seeds.			
23	Excellent Glass	Clear glass, fairly viscous but poured and fined easily.	34	Excellent Glass	Clear glass, melted and fined well, good durability.

in the results. The resistance to atmospheric corrosions was very good for these glasses, even at quite high rubidium contents.

The following table—Physical Properties of Rb_2O-PbO-SiO_2 Glasses—indicates the relation of the physical properties with the per cent oxide composition of the various members.

These results are comparable to properties of potash-lead-silica glasses except that the density, refractive index, and softening point are generally higher. In other words, the strong influence of the significant Rb^+ content is evident.

The coefficient of expansion of these glasses is most interesting. Generally speaking, the alkali content has the greatest influence on this property because most alkalies, such as lithium, sodium, and potassium, have a rather high coefficient of expansion, at least when compared with the other constituent oxides in the glass. These glasses confirm the same relationship: that is, the higher the RB_2O content, the greater the coefficient, and the lower the Rb_2O content, the lower the coefficient of expansion. These glasses are quite high in alkali (Rb_2O).

It appears that it is possible to develop a high alkali content rubidium glass which will not devitrify and which will possess good durability. It is now possible to have glasses with 20-40 per cent alkali content (Rb_2O).

It is of definite interest to compare these glasses with corresponding ones containing an equal percentage of

Table VII

PHYSICAL PROPERTIES OF Rb_2O-PbO-SiO_2 GLASSES

Point #	Per Cent Composition of Oxide: Per cent Rb_2O	Per cent PbO	Per cent SiO_2	Density	Index of Refraction (N_d)	Littleton's Softening Point (°C.) $\log\eta = 7.65$	Coefficient of Expansion (α alpha) 0.300°C.
17	40	10	50	3.11	1.520		
18	30	20	50	3.14	1.545	705	
19	20	30	50	3.27	1.575		
20	10	40	40	3.52			
23	50	10	40	3.30			
24	40	20	40	3.42	1.590	580	143×10^{-7}
25	30	30	40	3.63	1.595	615	128×10^{-7}
26	20	40	40	3.86	1.660		103×10^{-7}
27	10	50	40	4.39	1.710		
30	60	10	30				
31	50	20	30	3.16			
32	40	30	30	3.85			
33	30	40	30	3.91	1.650		146×10^{-7}
34	20	50	30	4.43	1.635	576	116×10^{-7}
35	10	60	30	4.73	1.71+		
41	40	40	20	4.16			
42	30	50	20	4.22	1.680		154×10^{-7}
43	20	60	20	4.78	1.720		

CALCULATION OF LINEAR COEFFICIENT OF EXPANSION
(α) OF CORRESPONDING POTASH GLASSES

Point #	Oxide	(% X Factor)		Point #	Oxide	(% X Factor)	
24	K_2O	40% X 2.83 =	113×10^{-7}	33	K_2O	30% X 2.83 =	84.9×10^{-7}
	PbO	20% X 1.00 =	20×10^{-7}		PbO	40% X 1.06 =	40.0×10^{-7}
	SiO_2	40% X .05 =	2×10^{-7}		SiO_2	30% X .05 =	1.5×10^{-7}
	(K_2O Glass—Calculated)		135×10^{-7}		(K_2O Glass—Calculated)		126.4×10^{-7}
	(Rb_2O Glass—Table VII Determined)		143×10^{-7}		(Rb_2O Glass—Table VII Determined)		146×10^{-7}
25	K_2O	30% X 2.83 =	84.9×10^{-7}	34	K_2O	20% X 2.83 =	56.6×10^{-7}
	PbO	30% X 2.83 =	30.0×10^{-7}		PbO	50% X 1.06 =	50.0×10^{-7}
	SiO_2	40% X .05 =	2.0×10^{-7}		SiO_2	30% X .05 =	1.5×10^{-7}
	(K_2O Glass—Calculated)		116.9×10^{-7}		(K_2O Glass—Calculated)		108.1×10^{-7}
	(Rb_2O Glass—Table VII Determined)		128×10^{-7}		(Rb_2O Glass—Table VII Determined)		116×10^{-7}
26	K_2O	20% X 2.83 =	56.6×10^{-7}	42	K_2O	30% X 2.83 =	84.9×10^{-7}
	PbO	40% X 1.00 =	40.0×10^{-7}		PbO	50% X 1.06 =	50.0×10^{-7}
	SiO_2	40% X .05 =	2.0×10^{-7}		SiO_2	20% X .05 =	1.0×10^{-7}
	(K_2O Glass—Calculated)		98.6×10^{-7}		(K_2O Glass—Calculated)		135.9×10^{-7}
	(Rb_2O Glass—Table VII Determined)		103×10^{-7}		(Rb_2O Glass—Table VII Determined)		154×10^{-7}

K_2O. In order to make this comparison, factors of Winkelmann and Schott[5] are used for calculating the coefficient of expansion of the corresponding potash glasses.

The following calculations show the difference in coefficient of expansion, α, of the rubidium glasses as determined, and the corresponding potash glasses as calculated from the factors of Winkelmann and Schott.

It can be seen that in each instance, the rubidium glass possesses a higher coefficient of expansion than the corresponding potash glass. These results correspond closely with the findings of Bezborodov and Bobkova,[6] who stated that cesium produced a higher coefficient of expansion. This influence is most desirable because it

(*Continued on page 454*)

[5] G. W. Morey, *The Properties of Glass*, Reinhold Publishing Corporation, New York (1945), 270.

[6] M. A. Bezborodov and N. M. Bobkova, *Thermal Expansion of Cesium Silicate Glass*, Doklady Akad. Nauk Beloruss, S.S.R. 1, No. 1, 13-16 (1957) (in Russian); Chem. Abs. *52*, 6771h (1958).

Table VIII

PHYSICAL PROPERTIES OF Rb_2O-BaO-SiO_2 GLASSES

Point #	Percent Composition of Oxide: Percent Rb_2O	Percent BaO	Percent SiO_2	Density	Index of Refraction (N_d)	Littleton's Softening Point (°C.) log = 7.65	Coefficient of Expansion (α) 0-300°C.)
8	20.0	10.0	70.0				
9	10.0	20.0	70.0				
12	30.0	10.0	60.0	2.84		710	139 X 10^{-7}
13	20.0	20.0	60.0	2.89	1.535	830	
14	10.0	30.0	60.0	2.95		765	
17	40.0	10.0	50.0	2.94	1.530	740	110 X 10^{-7}
18	30.0	20.0	50.0	3.09	1.540	765	
19	20.0	30.0	50.0	3.06	1.550	795	100 X 10^{-7}
20	10.0	40.0	40.0	3.26	1.575	832	
23	50.0	10.0	40.0	3.29	1.570	805	
24	40.0	20.0	40.0	3.28	1.590	760	135 X 10^{-7}
25	30.0	30.0	40.0		1.590	795	123 X 10^{-7}
26	20.0	40.0	40.0				116 X 10^{-7}
27	10.0	50.0	40.0	3.27	1.600		
30	60.0	10.0	30.0				
31	50.0	20.0	30.0				
32	40.0	30.0	30.0	3.58	1.595		
33	30.0	40.0	30.0	3.32	1.600		
34	20.0	50.0	30.0	3.38	1.605		
35	10.0	60.0	30.0				
42	50.0	30.0	20.0				

CALCULATION OF LINEAR COEFFICIENT OF EXPANSION (α) OF CORRESPONDING POTASH GLASSES

Point #	Oxide	(% X Factor)		Point #	Oxide	(% X Factor)	
12	K_2O	30% X 2.83 =	84.9 X 10^{-7}	24	K_2O	40% X 2.83 =	113.2 X 10^{-7}
	BaO	10% X 1.00 =	10.0 X 10^{-7}		BaO	20% X 1.0 =	20.0 X 10^{-7}
	SiO_2	60% X .05 =	3.0 X 10^{-7}		SiO_2	40% X .05 =	2.0 X 10^{-7}
		(K_2O Glass—Calculated)	97.9 X 10^{-7}			(K_2O Glass—Calculated)	135.2 X 10^{-7}
		(Rb_2O Glass—Table VIII Determined)	139 X 10^{-7}			(Rb_2O Glass—Table VIII Determined)	135 X 10^{-7}
17	K_2O	40% X 2.83 =	113.2 X 10^{-7}	25	K_2O	30% X 2.83 =	84.9 X 10^{-7}
	BaO	10% X 1.0 =	10.0 X 10^{-7}		BaO	30% X 1.0 =	30.0 X 10^{-7}
	SiO_2	50% X .05 =	2.5 X 10^{-7}		SiO_2	40% X .05 =	2.0 X 10^{-7}
		(K_2O Glass—Calculated)	125.7 X 10^{-7}			(K_2O Glass—Calculated)	116.9 X 10^{-7}
		(Rb_2O Glass—Table VIII Determined)	110 X 10^{-7}			(Rb_2O Glass—Table VIII Determined)	123 X 10^{-7}
19	K_2O	20% X 2.83 =	56.6 X 10^{-7}	26	K_2O	20% X 2.83 =	56.6 X 10^{-7}
	BaO	30% X 1.0 =	30.0 X 10^{-7}		BaO	40% X 1.0 =	40.0 X 10^{-7}
	SiO_2	50% X .05 =	2.5 X 10^{-7}		SiO_2	40% X .05 =	2.0 X 10^{-7}
		(K_2O Glass—Calculated)	89.1 X 10^{-7}			(K_2O Glass—Calculated)	98.6 X 10^{-7}
		(Rb_2O Glass—Table VIII Determined)	100 X 10^{-7}			(Rb_2O Glass—Table VIII Determined)	116 X 10^{-7}

Ream In Flat Glass

by Heywood J. Knighton

FORD MOTOR COMPANY

• THE GLASS DIVISION GLOSSARY defines *Ream* as "An imperfection; non-homogeneous layers in flat glass." For example, if one took two flat pieces of identical glass, sandwiched a relatively thin strip or layer of a different glass in between the two, and fused the assembly into a solid mass, the thin layer would constitute a "Ream." Similarly, two or more heterogeneous strips or layers, either in the same plane or in different parallel planes within a piece of flat glass, would constitute "Ream." Ream may assume different shapes within the glass matrix and may be located on or at varying distances from either surface of a piece of flat glass. It may lie generally parallel to the surfaces or it may be embedded at varying angles. The physical properties of ream may differ significantly from those of the glass matrix, depending upon their respective chemical compositions.

Fig. 1. An edge view of that type of homogeneous glass which we would like to make all the time. Because of the temperature gradient which existed through the glass thickness in the annealing range, mild permanent stresses were developed whose presence is indicated by the bi-refringence. By definition such stresses are considered permanent; however, in the manufacture of plate glass they may rightfully be classified as temporary, as they are substantially removed during the grinding and polishing process.

The writer has selected two specimens from his archives of past production difficulties which contain ream of the worst kind. Colored slides were prepared using the petrographic microscope with crossed Nicols, tint plate, and at a magnification of 75X. A similar slide was prepared from current production in order to demonstrate the difference between homogeneous glass and the "horror specimens." (It is to be emphasized that the following slides purposely represent extreme, exceptional, examples of ream).

We have defined *Ream* as non-homogeneous layers in flat glass. If, in practice, we arbitrarily scrapped all production which contained such layers, regardless of their intensity and effects, we would soon be out of business, because at our present state of proficiency, non-homogeneous layers of insignificant intensity are the rule, rather than the exception. We are spared from this predicament because a combination of circumstances are required in order for ream to result in defective glass. In practice, finished glass containing ream which is visible to the naked eye will result in image distortion. Such glass is considered defective and is therefore scrapped. If ream is not visible to the naked eye, there is no image distortion and therefore, such glass is considered "okay production."

The fact that a specific ream is visible, or invisible, to the naked eye and, consequently, determines whether the particular piece of glass is useful or defective, depends upon many factors including the following:

1. The type of light source.
2. The viewing angle.
3. The characteristics of the ream, such as thickness, abruptness of change from ream to matrix, index of refraction, and continuity of ream across its width.
4. The proximity and angle of the ream to the surface of the matrix.
5. The type of glass, i.e., plate or sheet glass.

When viewed by reflected light, objectionable ream appears to the naked eye as one or more straight lines which are oriented parallel to the original longitudinal edge of the ribbon of glass. When viewed in a polariscope, a typical ream is clearly visible because of the contrast between the color of the ream and matrix. The colors observed are a measure of birefringence. The birefringence is due to the internal stresses present, which in turn are caused by the difference between the coefficients of expansion of ream and matrix.

Upon cooling the ream will try to contract either more or less than the surrounding glass which results in the

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buildup of concentrated, internal stresses. By careful analysis of the colors present, the type and magnitude of such stresses may be calculated.

When plate glass is defective due to ream, it is because of two reasons:

1. Image distortion is produced because of the difference between the index of refraction of the ream and its matrix.
2. An imperfection is evident which detracts from the aesthetic beauty of the glass.

When sheet or window glass is defective due to ream, it is generally because of three reasons:

1. Image distortion is produced because of the difference between the index of refraction of the ream and its matrix.
2. Image distortion is produced because of the "lens effect" of the glass surface contour.
3. An imperfection is evident which detracts from the aesthetic beauty of the glass.

(The "lens effect" in sheet glass is due to the different temperature-viscosity relationship possessed by the ream and the matrix. In the drawing process the glass is partly "stretched" to its desired thickness. The uniformity of stretching is a function of glass viscosity symmetry. Thus, the ream may be stretched to a greater or lesser extent than its matrix. This results in one or more sharp ridges or grooves in either or both glass surfaces.)

In the manufacture of automobile windshields processing scrap due to ream, if existent, would be a function of the difference between the coefficients of expansion of ream and matrix. Such scrap would be evident in the form of glass breakage and would depend not only upon the magnitude of the internal stresses, but also upon their type, and the exact location within the matrix. It has been the writer's experience that ream resulting in moderately stressed internal layers has not constituted a significant scrap factor in either the grinding or polishing operations. He has, however, observed isolated cases where a minimum amount of grinding breakage was caused by surface ream.

Without question, the writer is unaware of all of the possible grinding and polishing breakage due to ream which may have occurred over the years; however, there have been several occasions when the plant was operating at peak processing efficiency, during which time the glass contained a considerable amount of invisible ream. The writer has silently suspected that the internally stressed layers were playing the role of "shock absorbers." (It should be mentioned that regular, periodic, polariscopic checks are made of the rough plate glass at the annealing lehr. All glass containing objectionable ream is scrapped at this point. This procedure should result in minimizing any subsequent processing losses due to ream.)

Once in the writer's history a study was made in order to determine if invisible ream was the cause of breakage in the windshield bending operation. Sections were obtained from approximately 200 windshield templets which had broken in the bending operation during a six-week period, together with sections from that part of each windshield assembly which did not break. Random samples were also collected from the templet cutting department in order to get a fix on the general quality of all the glass which was bent during that period.

All specimens were examined under the petrographic microscope with crossed Nicols and tint plate and were graded A, B, and C, depending upon (A) the absence of ream, (B) ream resulting in moderately stressed layers, and (C) ream resulting in considerably stressed layers. The study revealed that little, if any, correlation existed between ream and bending breakage during the period in question. (We therefore directed our search toward more practical aspects of the problem and found the answer.)

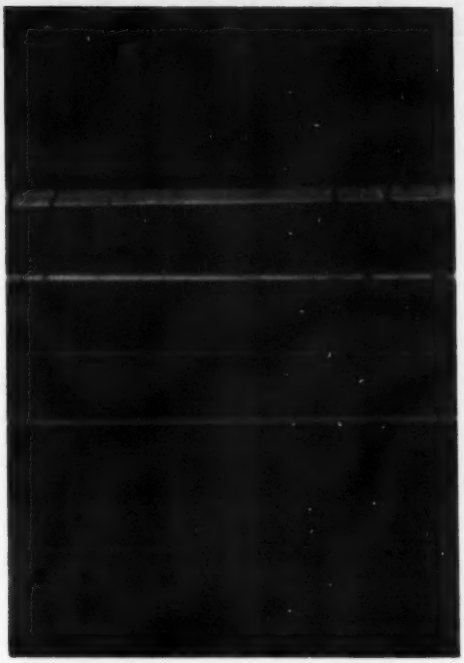


Fig. 2. Highly stressed, parallel, non-homogeneous layers which resulted from a scale error of considerable magnitude. Such stresses are developed because of the difference between the coefficients of expansion of the layers and of the glass matrix.

Now that the general characteristics and effects of ream have been described, its cause should be considered. The writer could present a list of theoretical reasons for ream, which would entail everything from moisture in raw materials to furnace atmosphere; instead, he will present a number of specific case histories of severe ream epidemics and hope that such data will justify a generalization on the subject.

Case History No. 1

For a short period of time in 1950 we contracted to grind someone else's glass on weekends. Because the glass composition was not too different from our own, and because only a small amount of cullet was expected to be generated, it had been decided that such cullet would be fed back into the glass melting furnace. Until this time the furnace operation was running smoothly and everyone was happy.

Concurrent with the introduction of the foreign cullet into the furnace, a ream condition developed which resulted in considerable intermittent scrap. Only after arrangements were made to send all of the foreign cullet to the dump did the ream condition clear up.

(*Continued on page* 443)

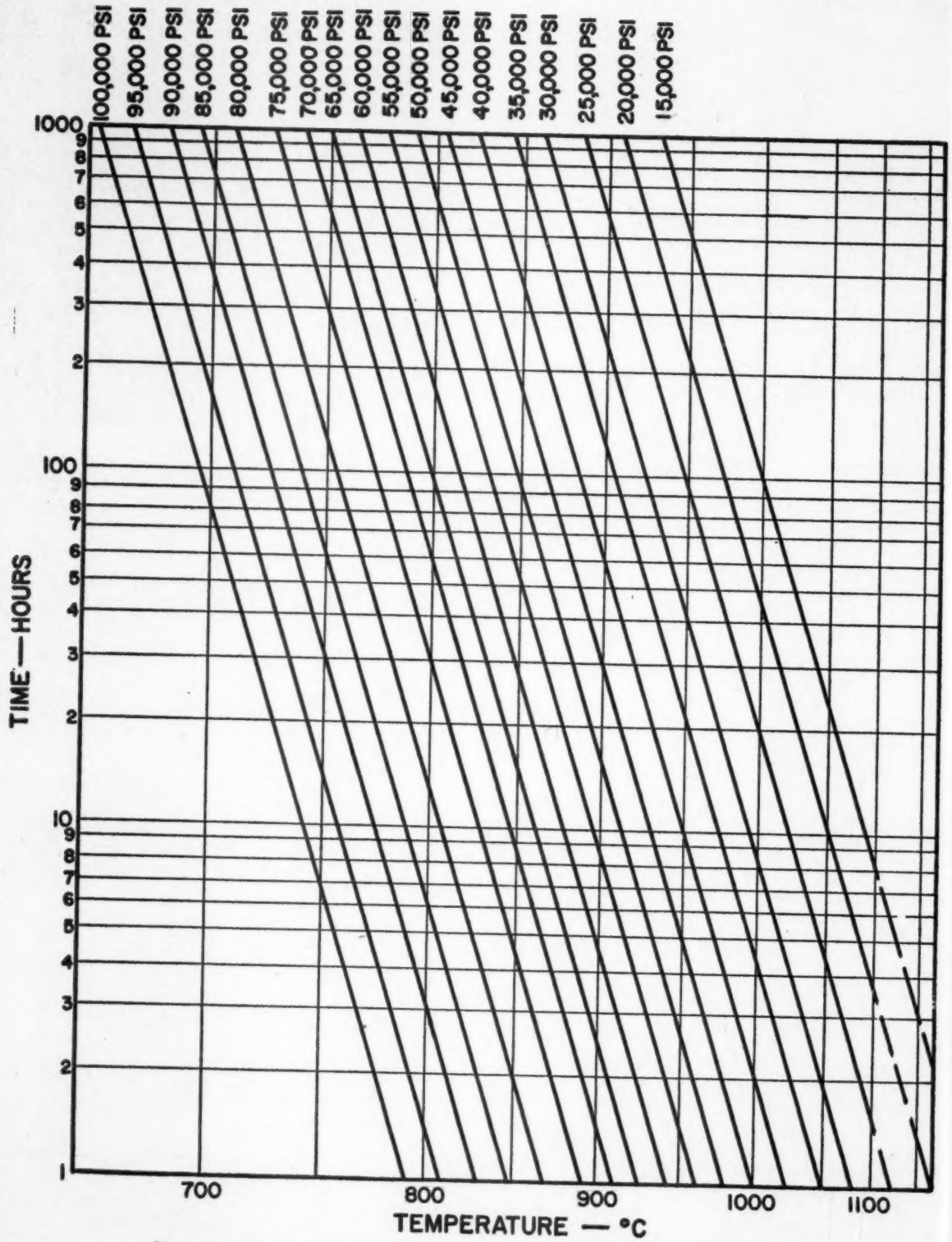


Fig. 4. Stress-rupture properties of Viscotherm 7. Data from 1100° C to 1300°C is extrapolated.

High-Temperature Alloys for the Glass Industry

by Bruce F. Richardson
PRODUCTS MANAGER, METALS DIVISION
KELSEY-HAYES COMPANY, NEW HARTFORD, N. Y.

• A NEW FAMILY of high-temperature, oxidation-resistant alloys[1] having extremely high hot strength is finding wide acceptance in the glass manufacturing industry in applications such as molds, pins, tips and other moving and stationary parts where temperatures up to 1300°C are encountered. These alloys, hardened with lesser amounts of aluminum and titanium, have a nickel base, with significant percentages of chromium, cobalt and molybdenum which strengthen the pure nickel and in certain proportions enhance its corrosion and oxidation resistance.

They are melted by induction in vacuum furnaces[2] for the removal of gaseous contaminants and heavier volatile impurities which normally accompany many alloys.

Nickel itself resists corrosion in air at temperatures up to about 800°C, but is soft and weak at higher temperatures (Figs. 1 and 2). Inconel, for example, has a room temperature strength of 80,000/100,000 psi, according to Hoyt[3], while "A" nickel in the same metallurgical condition has a strength of only 55,000/75,000 psi. Nickel-base alloys containing chromium, cobalt, and molybdenum in various combinations, but without the precipitation-hardening mechanism, have been used for quite some time in other industrial applications where corrosive conditions cause rapid deterioration of lesser metals.

The new family of "Viscotherm" alloys is a development of the Metals Division of Kelsey-Hayes Company, New Hartford, N. Y., for many years a leading manufacturer of superalloys by the vacuum induction melting process for jet aircraft and missile applications. Their ability to perform at 850°C and above is partly the result of a high-temperature aging phenomenon employing, in most cases, the Group III elements, aluminum and titanium, in the form of nickel compounds, and certain tiny carbide and cyanonitride particles which are placed in solid solution by means of a "solutioning" heat treatment.

The solutioning temperature is in the neighborhood of 1200°C for all Viscotherm alloys. The particles are reprecipitated at lower temperatures but in a much finer form by selecting "aging" temperatures which yield optimum mechanical elevated temperature properties. These properties for five of the alloys are shown in Table I.

Table I
ELEVATED TEMPERATURE PROPERTIES OF FIVE ALLOYS

	Temperature Range °C.	Oxidation Resistance	Hot Strength at Max. Temp.
VISCOTHERM 4	to 1250	Fair	Good
VISCOTHERM 5	to 1300	Excellent	Good
VISCOTHERM 6	to 1300	Good	Good
VISCOTHERM 7	to 1200	Good	Excellent
VISCOTHERM 1612	to 1300	Excellent	Good

Mechanical Properties

In the presence of nickel, aluminum and titanium can precipitate a phase of the Ni_3Al (Ti) type generally known as the "gamma prime", a face-centered cubic phase with an ordered structure. The operation of this phase as precipitated by a 16-hour treatment at

Table II
ROOM TEMPERATURE TENSILE STRENGTH VISCOTHERM 4 IN TWO CONDITIONS OF HEAT TREATMENT

Heat Treatment	Ultimate Tensile Strength
As solution-treated 1150°C, water-quench	123,000 psi
As solution-treated and aged 1150°C, water-quench 760°C, air cool	181,000 psi

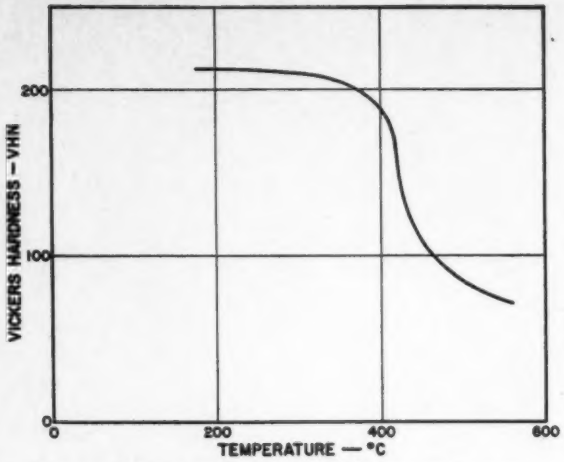


Fig. 1. Hardness of nickel in the 200-600°C temperature range.

760°C increases the strength of these alloys by perhaps 40 per cent. Table II shows a comparison between the room temperature strength of a Viscotherm alloy in the solution-treated condition, and in the solution-treated and aged condition. The solution heat treatment for Viscotherm 4 is 1150°C followed by cooling in still air, and in this condition Table II shows an ultimate tensile strength of 123,000 psi. By following this treatment with a double age as shown in the table, the strength jumps to 181,000 psi.

The strength of the alloys appears to go down very gradually as the temperature increases. Fig. 3 shows the change in strength of Viscotherm 5 with temperature from 900°C to 1300°C.

In addition to high hot strength, an important feature of this alloy series is long life at elevated temperatures and under high stress as measured by stress-to-rupture tests. This property, for Viscotherm 7 measured in air, is shown in Fig. 4.

Metallography

Because of the number of metallic elements present in these alloys and the interaction between combinations of phases in the different metallurgical conditions, their metallography is complex. The microstructure of a completely wrought, fully heat-treated sample of Viscotherm 5 is illustrated in Fig. 5 at 100 magnifications. Noticeable features of the microstructure are:

1. The presence of twinning. Twins seem to persist following hot working of all Viscotherm alloys except No. 1612.
2. The almost complete absence of grain boundary contaminants, said to be a function of vacuum induction melting.
3. Randomly dispersed individual larger grains in a fine-grain matrix. The nominal grain size is No. 3 on the ASTM scale in general; with randomly dispersed one's and two's. Although this has not been quantitatively established, it has been hypothesized that the large random grains contribute to the remarkable stress-to-rupture life of the alloys.

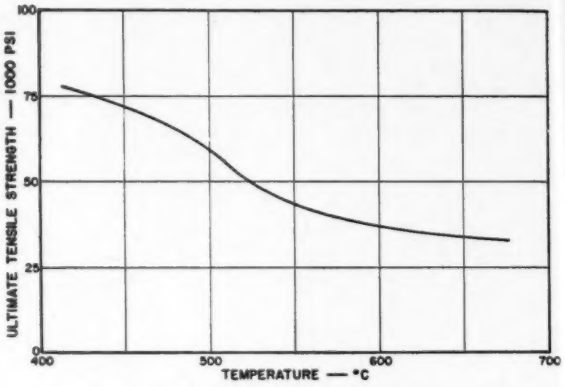


Fig. 2. Strength of nickel in the 400-650°C temperature range.

4. Absence of oxide, sulfide and otherwise "dirty" inclusions, also a function of vacuum induction processing.
5. The presence of carbonitride particles which have the effect of limiting any unrestricted grain growth at higher temperatures.

The resistance to oxidation, erosion, and corrosion of the family of alloys is brought about to some extent by the formation of a close-adherent, hard refractory oxide layer on the outside surface of parts in service. This oxide layer is portrayed at 300 magnifications in Fig. 6. It is noticeable how the oxide layer follows a discontinuity in the surface of the part.

Machinability

All of the alloys are machinable with carbide tooling. Since practically all nickel-base alloys are work-hardenable to the extent of several thousandths of an inch, all cuts should be designed to remove the worked layer. Rigidity of setup is of considerable importance, because, although the alloys are seldom harder than 38 on the

(*Continued on page* 445)

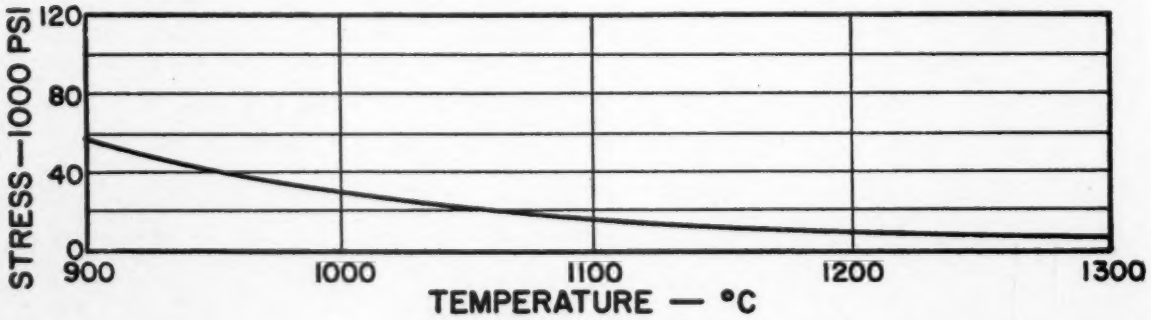
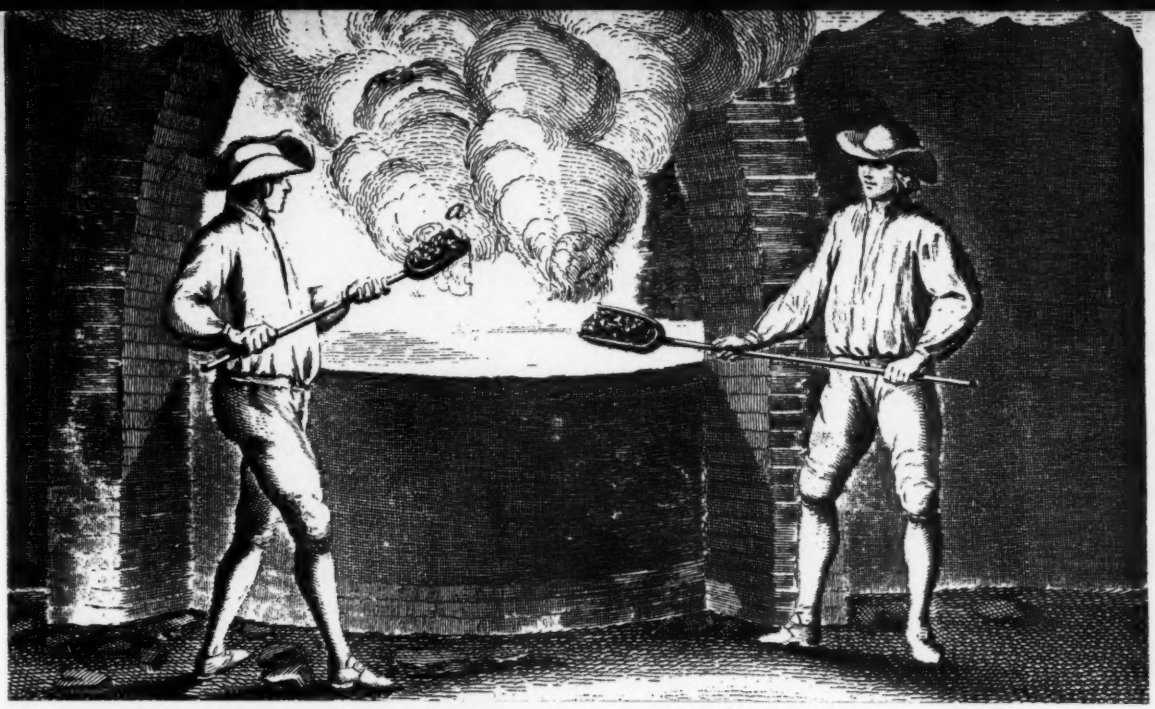


Fig. 3. Tensile properties of Viscotherm 5.



Furnace-men charging mixture of frit and cullet through opening (a) into a pot inside furnace.

Glass Manufacture in the 18th Century

• THE ART OF GLASSMAKING dates back to prehistoric times; however, the methods of basic manufacture were still closely guarded secrets in the 18th Century. During the late Middle Ages and the Renaissance, Italy was the European center for fine crystal and elegant mirrors. Venice, and the tiny duchy of Altara, near Genoa, were held in special esteem; indeed, the Venetians in the 16th Century were so proud and so jealous of their glassworks that any glass blower who traveled to another country to share his skills with foreigners was liable to the death penalty.

The Duke of Altara did not concur with this rigid policy and permitted his glass-blower subjects to take service in foreign lands, making sure first to collect royalties and a lifelong percentage of their earnings.

Inevitably the Italian technique of glass blowing gradually spread to other lands and became well known in France, where the native glass industry had been highly respected since the Middle Ages and French glass workers of the 18th Century enjoyed aristocratic privileges. Some authorities believe their special status arose from the importance of the glass-blowing art itself; others feel the high rank of the glass blower had its origin during the time of the first glassmakers in France who were actually enterprising noblemen. They had discovered that making glass was more profitable than being lords of the manor.

It was at the height of this 18th Century period that Denis Diderot published his *Pictorial Encyclopedia of Trades and Industry (L'Encyclopedie, ou Dictionnaire Raisonné des Sciences, des art et des Métiers)*, the main purpose of which was to encourage the growth of industry by revealing trade secrets that had been concealed from outsiders by trade monopolies for generations.

The original Encyclopedia (Volume I was published in 1751; Volume II, 1752) included some 2,900 plates, mainly on arts and crafts, but also on the sciences, engineering, fine arts, sports, heraldry, and other subjects.

A condensed, 485-copperplate version of the original set of two volumes has just been published by Dover Publications, Inc., New York, who have taken great care to reproduce the engravings, wherever possible, in full size.

Among all of the trades covered by M. Diderot in the original volumes, glass making was given special attention because of its great secrecy. The authors of the reprinted volumes have accordingly reproduced 67 copperplates devoted to glass manufacturing in Volume II.

Detailed illustrations show typical glass furnaces, as well as methods of blowing goblets, and making bottle, crown, broad and plate glass.

These represent a fascinating panorama of glass-making methods during that era and vividly portray the craft as it was in its infancy.

LEAD SULPHIDE FILMS

Part two *by Samuel Wein,* CONSULTANT

Lead Nitrate Techniques

This is a companion process developed by Reynolds, the inventor of lead sulphide film formation.

1) Sodium hydroxide	16 grams
Water	1.75 liters
2) Lead nitrate	17 grams
Water	250 cc.

Combine solutions *1* and *2* and raise the temperature to 90° C. The reaction product, formed by the two solutions, is filtered through asbestos or glass wool. Then to the filtrate add the following:

3) Thiourea	4 grams
Water	1000 cc.

If the solutions are used at room temperature, the lead sulphide film will form at a much slower rate than if used at a somewhat higher temperature.

Peacock, a well known mirror investigator offers the following three-solution formulation:

1) Lead nitrate	2 ounces
Water	32 "
2) Sodium hydroxide	4 ounces
Water	32 "
3) Thiourea	2 ounces
Water	48 "

This may be applied hot or cold to the glass surface. A mixture for application while hot consists of:

Water	4 ounces
Solution 1	1 ounce
Solution 2	1 "
Solution 3	1 ounce

The solutions are mixed in the order given. Solution *3* is not added to the final mixture until just before the latter is poured onto the glass surface to form the lead sulphide film.

It takes about 15 minutes for the lead sulphide to precipitate out of the final solution and form a film on the glass. The excess solution is removed with a piece of chamois, after which the deposited film is wiped to obtain a clean, metallic surface. A second coating may be deposited out of solution, built up on the first film, again wiped with the chamois, washed with running water, and dried. If the deposited film shows dark spots, which would indicate the presence of moisture, it is given a protective coating of shellac dissolved in alcohol.

Addition Agents

As in the case of silver mirror making, lead sulphide films with addition agents in varying amounts have been suggested in the literature. A review of the known references follows:

Bruckman added tin as well as antimony, Colbert and Morgan have patented the addition of gold, antimony, molybdenium, thallium, zinc, cadmium, copper and silver. Hansell has recorded the addition of selenium for photocell use.

Pick studied the formation of lead sulphide films using acetate formulations under a variety of conditions, and found that if the reaction velocity is too great, an adherent deposit is not obtained. If the concentration of the solution is too slow, a poor film is formed. The addition of a very small amount of copper sulphate resulted in the formation of excellent reflecting surfaces.

Colbert and Morgan add metal salts such as gold, antimony, molybdenium, thallium, zinc, copper or silver to their version of the lead acetate solution in order to correct the optical transmission of the film first formed. In other words, by adding any of these metals (their proportions may likewise be increased or decreased in the lead sulphide solutions prior to the formation of the film), a combined transmission or absorption value of the metals precipitated out on the glass will result.

Hansell reports that the German workers have added selenium to the lead sulphide solution during its manufacture, and, as a result have decreased its infra-red sensitivity to wave lengths of 4 to 5 microns.

The lead sulphide-selenium compound is precipitated out of solution by means of a reaction between a solution of lead acetate and selenious acid and thiourea solutions. No alkali hydroxide is used in this case, and the reaction is best carried out at higher temperatures than that used to form the lead sulphide films. Otherwise, the process and cell manufacture is believed to have been about the same as that employed in making lead sulphide films.

Chemical Purity

Of necessity, the purity of the chemicals used must be of the highest possible order, since impure chemicals will yield inferior or unreliable films. Chemically pure grades are preferred, but "commercially pure" grades may also be used.

Water

Distilled water is usually used for such purposes as this. Mineral waters contain metal salts and chlorides, which will interfere with the proper formation of lead sulphide films. Demineralized water ("deionized") may be used in the place of distilled water with good results.

Alcohol

Denatured by the addition of wood alcohol, 1 part in 20, may replace pure grain alcohol. This composition is denatured in accordance with "Formula 3-A" of the Bureau of Internal Revenue, Commercial "rubbing alco-

hol". It has been satisfactorily used by Gardner and Case in silvering solutions and ought to serve well here.

Acetic Acid

A colorless liquid having a decided acid odor. Chemical formula is CH_3COOH; molecular weight, 60.05.

Ammonia

A colorless solution of a gas in water, with the chemical formula, NH_4OH. Specific gravity is 0.897 at 15° C. (28 per cent).

Lead Acetate

Available as a white crystal or brown powder; readily soluble in water. Chemical formula is $Pb(C_2H_3O_2)_2 3H_2O$; molecular weight, 379.35.

Lead Carbonate

A white powder insoluble in water. Chemical formula is $PbCO_3$; molecular weight, 267.3.

Lead Nitrate

A colorless crystal, with the chemical formula $Pb(NO_3)_2$. Readily soluble in water.

Lead Tartrate

Not readily available, but it can easily be formed by the reaction between a suitable lead salt (water soluble) and sodium potassium tartrate (Rochelle salts).

Sodium Hydroxide

This chemical is used to form the complex compound and to accelerate its reaction. It is available commercially as a powder, granule or plates. Readily soluble in water. Chemical formula: NaOH.

Triethanolamine

During an investigation of the properties of triethanolamine, the late Professor Meltsner noticed that this compound reduced aqueous solutions of lead salts. No details were given of this compound, although other metals were studied in details.

Thiourea

Also known as thiocarbamide, sulfocarbamide, and sulfourea. Thiourea differs from urea in that the thiourea molecule has an atom of sulfur in place of the oxygen atom of the urea molecule. Thiourea is readily water soluble and available in crystalline powder form. Chemical formula: NH_2CSNH_2.

Organic thiourea compounds such as diethyl, dibutyl and the ethylene derivaties are now the subject of investigation by experimenters.

REFERENCES

The U. S. Government PB-Reports

The U. S. Department of Commerce, Office of Technical Services, Washington, D. C. has the following "PB-Reports", dealing with the methods for forming the lead sulphide films and the many applications resulting from the processes reviewed above.

Orders for reports which are available in printed or mimeographed form should be directed to the Office of Technical Services. Orders for other types of reproduction such as microfilm, enlargement prints, and photos should be forwarded directly to the United States Library of Congress, Photo-Duplication Service, Publication Board Project, Washington 24, D. C.

The "PB" publications are as follows.

No. 2,211. Specifications and translation covering the manufacture and processes of lead sulphide infrared photo-electric cells. Text in German; 6 pages.

No. 3,536H. Hinterberger. Influences of gases, especially oxygen, upon the electrical properties of lead sulphide films. Text in German; 5 pages, 1945.

No. 19,435. Methods of setting-up electrically conductive layers on electrically non-conducting plastics, especially lead sulphide. Text in German; December 1944.

No. 31,594. C. W. Hansell, Miscellaneous Developments in German Science and Industry, June 1945; 36 pages.

No. 78,621. H. Pick. The Photo-electric Sensitivity of Lead Sulphide. Text in German, March 1947; 28 pages with graphs.

No. 81,123. E. Kutscher. Formulas for the manufacture of selenium and lead sulphide mirrors; 23 pages. Translation *No. 1084*, AAF-T-2.

No. 96,902. B. B. Gaddens. Electric and photo-electric properties of lead sulphide and lead-selenide, Part X, 1949, 4 pages.

No. 96,903. M. Treau. Properties of lead sulphide photo resistances, Part X1; March 1949; 7 pages.

No. 96,904. E. Kutscher. Lead sulphide photo-cells for electr-acoustics, Part XIII, March 1949, 8 pages.

No. 96,905. Sommer, H. Test procedure for lead sulphide for photo-cells, Part XIV, March 1949, 6 pages.

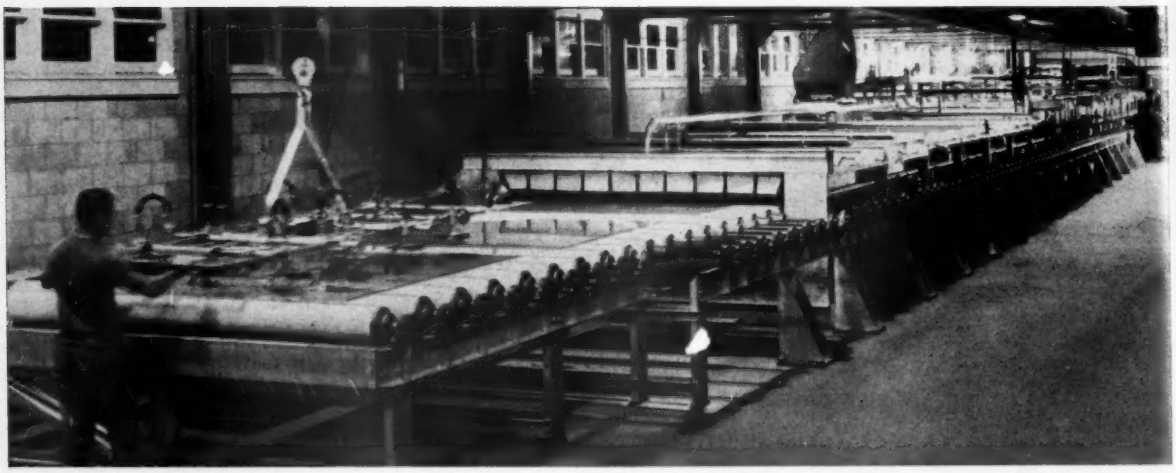
(*Continued on page* 446)

replacement pays off in lower unit cost

Sometimes only competition—from other materials and other countries—can force a manufacturer to recognize that his equipment belongs in a museum and his unit costs wear high-button shoes.

Fortunately, few managements need a crisis to remind them of the best cures for a case of competition. They consistently invest in process and product improvements, and in equipment which trims unit costs to competitive levels.

Because the investment yields gratifying returns, many companies regularly replace obsolete equipment with Surface Combustion lehrs, kilns, and ovens. The dependable productivity of these modern units is a pleasant antidote for competition.



A Surface Combustion continuous lehr for reannealing heavy sheet glass.

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2378 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

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Surface

NEWS in The Glass Industry

Fall Meeting of ACS Glass Division

The Glass Division of the American Ceramic Society will hold its fall meeting at Galen Hall near Wernersville and Reading, Pa., October 15 and 16.

The first session will be a symposium on Radiation Effects in Glass organized by Norbert J. Kreidl, chemical research director at Bausch and Lomb Optical Company, Rochester, N. Y.

Review papers will cover three areas. J. R. Hensler, Chemical Research laboratory, Bausch and Lomb, will discuss absorption effects; S. D. Stookey, manager of fundamental chemical research, Corning Glass Works, will describe nucleation effects; and Robert J. Ginther, Naval Research Laboratory, Washington, D. C., will speak about luminescence effects. Additional sessions will include recent papers, or those still in progress, in order to complete the coverage of current knowledge of radiation effects in glass.

A workshop on strength measurements on glass conducted by Neill M. Brandt, senior fellow, Mellon Institute, will also be included.

New District Managers—Armstrong

P. W. Triplett, John H. McCrea and H. Glen Eshleman have been appointed District Managers for the glass and closure division of Armstrong Cork Company in the Chicago, Detroit and Cleveland offices, respectively.

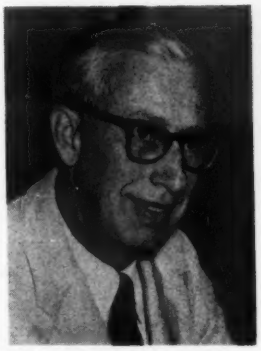
Owens-Illinois Offers Two Fellowships

Two fellowships are being offered by Owens-Illinois Glass Company for advance studies in glass. They are part of the company's expanding activities in the field of fundamental research and will be held at Ohio State University and Brown University.

Professor E. Leonard Jossem of Ohio State's Physics Department will direct one fellowship. This will entail investigation of the changes in glass surfaces produced by bombardment with the nuclei of argon atoms, causing various kinds of disorganization of the glass structure at, and immediately adjacent to, the surface of the glass. The investigation will involve the study and measurement of the total reflection of x-rays from the damaged glass surfaces in order to gain information regarding the density and thickness of the damaged surface films.

The second fellowship, concerning the application of a new technique for studying glass structure, will be supervised by Professor Philip J. Bray of Brown University's Physics Department.

The technique concerns the magnetic resonance properties of various atomic nuclei in glasses and should give valuable information of the nuclear environment of atoms in glasses.



Dr. Norbert J. Kreidl

Dr. J. R. Hensler

Dr. Stanley D. Stookey

Dr. Robert J. Ginther

Appointed by A. P. Green Fire Brick

Charles W. Glunk has been appointed manager of basic sales and service for A. P. Green Fire Brick Company's new refractory plant in Tarentum, Pa., which will produce magnesite, magnesite-chrome, chrome-magnesite, chrome and allied products such as mortars, castables, plastics and ramming mixes.

Dr. Atma Ram Receives State Honor

Dr. Atma Ram, director of the Central Glass & Ceramic Research Institute in Calcutta, India, and his country's representative to the International Commission on Glass, has been awarded the Padma Shri. This state honor, conferred on India's 10th Republic day, is in recognition of Dr. Ram's contributions to glass and ceramics.

Glass Tempering Ass'n. Annual Meeting

W. A. Williams, president of the Dearborn Glass Company, was re-elected to the board of directors at the first annual meeting of the Glass Tempering Association.

Reports were given on preliminary studies in various uses of tempered glass to provide detailed information for development of minimum acceptable specifications for adoption by the industry.

Lillie President of Int'l. Commission on Glass

H. R. Lillie, staff research manager, Research and Development division, Corning Glass Works, was installed as President of the International Commission on Glass at the final session of the Fifth International Glass Congress in Munich, Germany, last month.

Dr. C. H. Greene, professor of Glass Technology, New York State College of Ceramics, Alfred University; Dr. A. B. Bestul, staff member of the National Bureau of Standards; and Dr. Sydney Bateson, Duplate Canada, Ltd., were elected American representatives for three-year terms. Dr. N. J. Kreidl, chemical research director for Bausch and Lomb Optical Company, will continue as a representative and a member of the executive committee. He has held these posts for several years.

Dr. Lillie, who has served on the Commission since 1950, has been on the Executive Committee for several years. During the 1958 annual meeting in Brussels he became President-elect and assumed the duties of President at the close of the Fifth Congress. He succeeds Dr. B. P. Dudding of General Electric Ltd., England, and at the end of his three-year term will be succeeded by the new President-elect, Dr. Niels von Bülow, of Deutsche Glastechnische Gesellschaft.

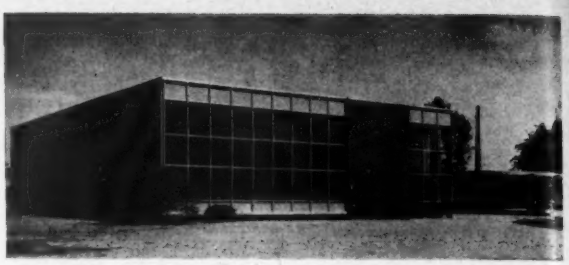
With Corning Glass Works since 1927, Dr. Lillie was manager for the Fundamental Physics department prior to his present post.

Republic to Open Plant in Manila

The Republic Glass Corporation is completing the first window, sheet and plate glass plant in the Philippines, located at Manila.

The operation is expected to begin next month with a production rate of 16,000 metric tons a year and should reach 21,000 tons by 1960. The plant's equipment includes a 120-foot furnace, automatic vibratory feeders, automatic cutting machines, electronic control systems and drawing equipment to pull window glass from the oven.

John L. Gushman (center), vice president and general manager, and O. R. Hecht (left), general sales manager, Owens-Illinois, accept special scroll from George Browne (right), editor of Industria. The scroll honors O-I's Cuban plant as one of the five most modern plants built in Latin America in 1958.



New engineering building (left) and rotunda entrance which has been added to the Technical Center of Libbey-Owens-Ford Glass Company.

Addition For LOF Technical Center

A $1,350,000 expansion project for Libbey-Owens-Ford Glass Company's Technical Center at Toledo, O., has just been completed with over 38,000 square feet having been added.

The ground floor houses offices on the south side and a large drafting area for furnace, general services and maintenance sections. The second floor has drafting rooms for the mechanical and structural sections, technical library and controlling offices.

Modernization of the research-development wing is scheduled to be completed early this month. It will house administrative offices including those of William H. Hasselbach and H. M. Alexander, vice presidents of engineering and technical services respectively; Dr. Joseph D. Ryan, general director of research and development and Dr. George B. Watkins, chairman, technical policy committee.

Libbey Glass Div. Promotes Roper

Cliff M. Roper, Jr. has been promoted to sales promotion manager for the Libbey Glass division of Owens-Illinois Glass Company, Toledo, O.

Arthur Named Refractories Institute President

J. B. Arthur, founder of Mexico Refractories Company, a division of Kaiser Aluminum & Chemical Corporation, was elected president of The Refractories Institute at the directors meeting on June 25 at White Sulphur Springs, W. Va.

O-I Cuban Plant Receives Award

Owens-Illinois' new glass container plant in San Jose de Las Lajas, 30 miles southeast of Havana, Cuba, was chosen as one of the five most modern plants built in Latin America during 1958.

George Browne, editor of Industria, international business magazine, presented a scroll in honor of the plant's selection to John L. Gushman, vice president and general manager of O.I.'s International division, and O. R. Hecht, general sales manager of the division.

Selection of the plant was based on its highly efficient production methods, esthetic and functional design, structural simplicity, and opportunity for expansion.

The plant makes a complete line of glass containers ranging in size from 5 cc. to gallon jugs, including beer, beverage, and milk bottles, food jars and drug and chemical containers.

Steimke Promoted to Vice President

Frank C. Steimke, research director, has been promoted to vice president in charge of manufacturing and research for the Walsh Refractories Corporation, St. Louis, Mo. He has been active in research and development in fire clay brick, cements, castables, coatings, plastics and the field of glasshouse refractory materials at the company's Vandalia works.

Nettleton rejoins NBS

Dr. Richard Nettleton has rejoined the staff of the National Bureau of Standards after a two-year postdoctoral study in the chemistry department at Rice Institute, Texas. He will work in the Mineral Products division and will carry out theoretical investigations of transport and other irreversible processes in liquids.

Dr. Nettleton will also study possible application or adaptation of existing theories of these processes to the kinetics of glass formation.

American-St. Gobain Plans Expansion

American-St. Gobain Corporation is planning to build a $50-million flat glass plant in the Ohio Valley area which will be completed by 1962.

In order to finance this expansion, the company has entered into an agreement for the sale to the Prudential Insurance Company of America of up to $33 million of 6 per cent First Mortgage Bonds due April 1, 1982, and warrants for the purchase of 200,000 shares of common stock at an aggregate consideration of $33 million.

The company also filed a registration statement with the Securities Exchange Commission (on June 26) to seek a registration of $11,221,500 Subordinated (convertible) Debentures due 1983 and 544,314 shares of Common Stock. American-St. Gobain proposes to offer the debentures for subscription at 100 per cent of principal amount by holders of its common stock at the rate of $100 of debentures for each 8 shares of common stock held.

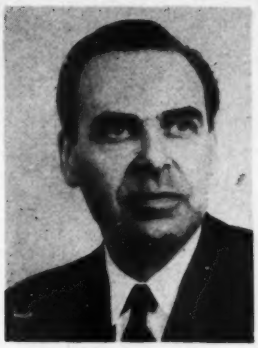
The common stock also is to be offered for subscription by common stockholders at the rate of one new share for each 3⅓ shares held.

Societe Anonyme des Manufactures des Glaces et Produits Chimiques de St. Gobain, Chauny et Cirey, the parent company, is purchasing 275,000 common shares at the subscription price to stockholders, under an option contract dated March 19, 1958, and 153,600 shares and $6,400,000 of debentures, at the subscription right.

A portion of the net proceeds of the sale of the debentures and common stock will be applied to the retirement of $3,950,000 of long-term debts; the balance will be applied to the cost of constructing the new plant.

American-St. Gobain Corporation was formed in 1958 by the merger of American Window Glass Company, Pittsburgh, and Blue Ridge Glass Corporation, Kingsport, Tenn., and operates plants at Arnold and Jeannette, Pa.; Okmulgee, Okla.; and Kingsport.

Frank C. Steimke



David W. Mitchell

Mitchell named to Research Post

David W. Mitchell has been named coordinator, research and production, at Foote Mineral Company. He will continue to act as manager of minerals research in addition to his new post.

Dr. Mitchell has been engaged in mineral beneficiation research since 1957 at the company's lithium mine in King's Mountain, N.C.

1962 Glass Congress in U. S.

The International Commission of Glass has accepted an invitation extended by the American Ceramic Society to hold its Sixth International Congress on Glass in the United States. It is tentatively scheduled for the week of July 1, 1962, in Washington, D. C.

$95,000 Contract for Pyroceram Mountings

A $95,000 development contract awarded to Corning Glass Works, Corning, N. Y., by the Applied Physics Laboratory of Johns Hopkins University will be used to improve the methods for mounting Pyroceram missile radomes. The primary objective of the program is to develop a mounting device capable of with-standing higher temperatures and greater aerodynamic loads encountered in higher missile speeds.

Eugene Hoyet, right, Pittsburgh Plate Glass Co., and James R. Tinklepaugh, director of the Air Force Project at State University of New York College of Ceramics at Alfred University, discuss samples of rough plate glass and finished ground plate glass during Abrasives Symposium held by the College of Ceramics. Mr. Hoyet lectured on "Use of Sands in Grinding and Polishing."

Harold M. Alexander

Eugene W. Fichter

Alexander, V. P., Technical Services

Harold M. Alexander has been promoted to vice president, technical services, of Libbey-Owens-Ford Glass Company. He will furnish glass technical services to automotive customers and will coordinate production to styling and engineering requirements.

LOF to Purchase 874 Acres

Libbey-Owens-Ford Glass Company has announced it will exercise its option on 874 acres of land approximately ten miles south of Stockton, Calif.

The ground is intended as a potential industrial site. The company does not intend to build a glass factory on the property in the near future; however, the company states, this move is part of a long-range planning program to prepare for possible western expansion.

Blanks for Aerial Camera Windows

Corning Glass Works' Harrodsburg, Ky., plant has produced seventeen crown borosilicate glass blanks to serve as aerial camera windows in the Lockheed-Air Force RC-130A photo mapping plane. The blanks, said to be the largest ever produced, are 43 inches in diameter, three inches thick and weigh 300 pounds each. Ground and polished by the Thompson Optical Engineering Company, Los Angeles, Calif., the blanks had to have an optical quality measured within millionths of an inch.

43-inch glass blanks produced by Corning Glass Works for Thompson Optical Engineering Co., to be installed as aerial camera windows on the Lockheed Air Force RC-130A photo-mapping plane.

Hazel-Atlas appoints Fichter

Eugene W. Fichter has been appointed manager of west coast manufacturing operations at the Hazel-Atlas Glass division of Continental Can Company. He will supervise the company's operations at Oakland Pomona, Calif.

Refractory Specialty of H. K. Porter

The refractories division of H. K. Porter Company, Inc., Pittsburgh, Pa., has begun full production of the first basic refractory specialty called Plastikrom. A plastic chrome ore, it is said to have a high resistance to basic slags, high air-setting strength, good refractoriness and excellent workability. These factors enable the ore to resist heat, abrasion, chemical attack, and deformation in various industrial furnaces.

The principal applications of the refractory are linings in glass furnace ports and checker chamber floors.

Artist's sketch of Owens-Illinois' new 305,000 sq. ft. warehouse in North Bergen, N. J. which will be completed early next year.

O-I Breaks Ground for N. J. Warehouse

Owens-Illinois Glass Company has broken ground for their new 305,000 square foot warehouse in North Bergen, N. J. Built as a glass container warehouse, the structure will be a one-story, steel frame building located on a triangular 72-acre tract with facilities for loading and unloading 22 trucks and 11 railway cars at one time. It is scheduled for completion early in 1960.

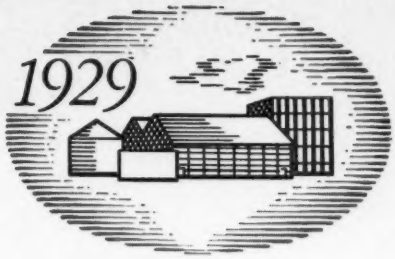
Morey To Receive Howard N. Potts Medal

Dr. George W. Morey, staff member of the U. S. Geological Survey, will be awarded the Howard N. Potts Medal from The Franklin Institute on October 21. The citation reads: "In consideration of his researches culminating in the production on a commercial scale of glasses composed of rare earth oxides and little or no silica, possessing a high index of refraction and a low dispersive power."

The medal is awarded by the Institute for distinguished work in science or the arts, important development of previous basic discoveries, inventions of products of superior excellence or utilizing important principles.

Dr. Morey developed the glass used in modern high-speed photographic lenses and also in wide-angle lenses for aerial photography. His principal research is the study of water systems of high temperature and pressures corresponding to the depths of the earth under many miles of rock. This includes the study of silicate mixtures.

TODAY *as in 1929*



there are clear advantages to WEST END SODA ASH

Supplying soda ash to meet the full requirements of western glass container producers has full-time priority at West End. From our first commercial manufacture in 1929 for a pioneer western glass container plant to today's large-scale production incorporating precise quality controls, ample storage and a unique system of fast, dependable service, West End has geared its progressive expansion specifically to the changing needs of this dynamic industry. It is only from the sound, functional base unique with West End that long-range dependability and realistic economy can be assured.

Coarse Dense Glassmakers' containing 1% $Na_2B_4O_7$

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DIVISION OF Stauffer STAUFFER CHEMICAL COMPANY

John C. Hawes

Hawes Appointed at Brockway

John C. Hawes has been appointed manager of marketing, advertising and promotion for Brockway Glass Company and will be responsible for marketing, advertising and promotional plans at Brockway, Pa., the Demuth Glass Works, Inc., Parkersburg, W. Va., and the Tygart Valley Glass Co., Washington, Pa.

LOF Appoints Two Technical Directors

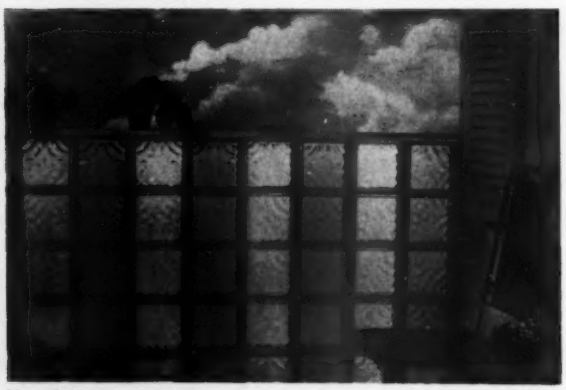
William P. Bamford and Robert P. Gibbs have been appointed directors of glass specifications and glass quality control, respectively.

Mr. Bamford succeeds Frank A. Rodman, who will retire January 1, 1960. Mr. Bamford began with LOF in Toledo, O., and in 1935 was transferred to the Rossford, O., plant where he worked in the development of bending and tempering processes.

Hollow, Colored-Glass Block by Kimble

Kimble Glass Company, subsidiary of Owens-Illinois Glass Company, is producing a hollow colored-glass block. A blue-green shade was selected because of its pleasant, cool appearance and its ability to reduce sun brightness and solar-heat transmission.

Research for the block was carried on by the Owens-Illinois Technical Center which developed a process permitting both green and colorless glass to be drawn from one furnace at the same time. It is manufactured in 8- and 12-inch sizes.



New hollow, colored-glass blocks of Kimble Glass Company which have been made in a blue-green shade to reduce sun brightness and solar heat.

Corning Produces Porous Nickel

A pressed and sintered porous nickel, capable of operating at temperatures up to 575° F. is being produced by Corning Glass Works.

The material, Cormet A, fabricated by a new process, permits more uniform porosity of the nickel. Pore diameter can be tailored to specifications between the limits of 1 to 45 microns. It is processed into sheets 12 by 30 inches; cylinders two feet in length, with 12-inch diameters; and piping, elbowed or straight chutes. The product is used by the glass industry as a non-contacting chute for molten glass, as chute marks and wrinkles are eliminated by carrying the molten glass on a cushion of air from the furnace to the mold.

Fine orifice holes (0.012 inch) for burner plates can be drilled by conventional metalworking machinery through thicknesses up to 5/8 inch.

Biggers (L-O-F): on Russian Glass Industry

John D. Biggers, chairman of the board, Libbey-Owens-Ford Glass Company, visited Russia for 12 days in May with his wife and son-in-law and daughter, Mr. and Mrs. Marvin Rorick, Jr. On his return, Mr. Biggers' impressions of the trip were published in the *Toledo (Ohio) Blade* on June 21.

Of the Russian glass industry, he reported:

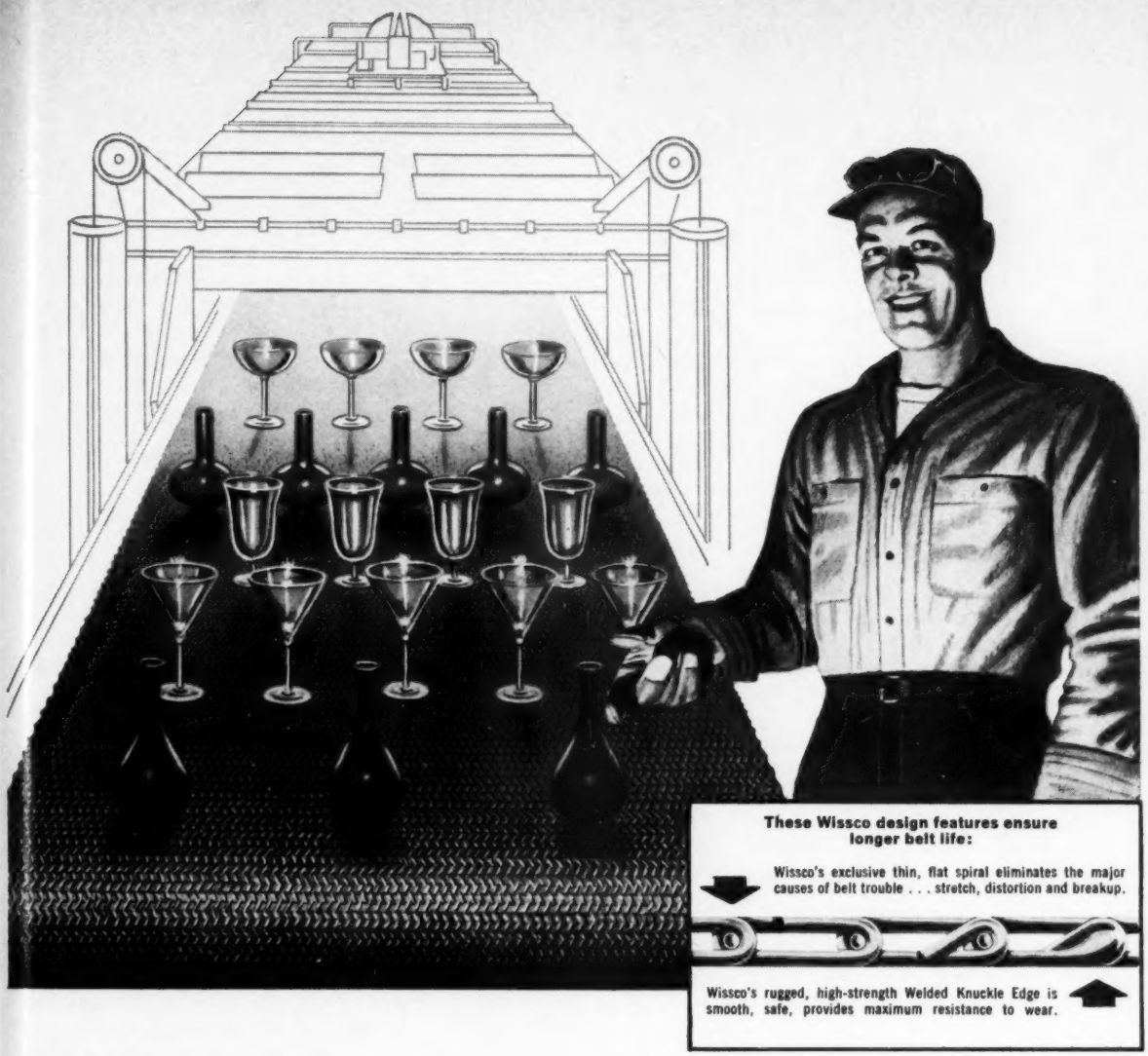
"Through the courtesy of Yuri A. Zhukov, chairman, USSR Committee for Cultural Relations with Foreign Countries, I had the privilege of meeting with 10 leaders of the Russian glass industry the last day I was in Moscow. They verified information which I had obtained from British sources to the effect that Russia during 1958 had manufactured 133 million square meters of window glass, which is more window glass than was made by any other country in the world during that year.

"The Russians were quite modest about this achievement. They said, 'Yes, we made that large quantity of glass but it is a very poor quality. Glass manufacture is one of our backward industries. We are not proud of our accomplishments.'

"Their reference to inferior quality was justified, but the quantity produced from 23 factories by a comparatively obsolete process was in itself a notable achievement.

"In other branches of glass making I found the production small, but the scientific research and engineering progress worthy of note. They are manufacturing plate glass in moderate quantity by a process similar to that generally used by American plants up to five years ago. From their basic glass they fabricate laminated glass for automobile windshields and tempered plate glass for sidelights and backlights. They also make fiber glass, glass block, rolled and figured glass and even heavy plate glass doors such as those used today in many American banks and shops.

"So even in this so-called 'backward industry,' strides have been, and are being, made which forecast severe competition for our American products in the neutral markets of the world and eventually within the borders of our own country."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- **are of open mesh construction.** They permit heat to flow freely, uniformly, simultaneously to all parts of all units being processed.
- **have a low thermal capacity.** They absorb relatively little heat, with resulting good thermal efficiency.
- **make minimum surface contact with the ware.** Consequently strain, bottom cracking and checking are reduced at points of support. Yet tall, slender, small-bottom ware is carried safely, smoothly without tipping.
- **are thoroughly washed and degreased** prior to shipment.
- **are available in both Balanced Spiral and Rod Reinforced weaves** . . . in Steel and Low Chrome alloys for use where temperatures will not exceed 1100°F . . . and in High Nickel Chrome analysis alloys to withstand operating temperatures to 2100°F.

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CF&I OFFICE IN CANADA: Montreal

6877

INVENTIONS AND INVENTORS

Annealing and Tempering

Inspection of glassware by radiation. Patent No. 2,868,061. Filed October 26, 1954. Issued January 13, 1959. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by William J. Fedorchak, Richard L. Early, and James W. Johnesee.

The present invention provides a system in which dual light sources are employed, preferably concentrated-arc lamps being used as the light sources. Radiation from both lamps is directed against the surface under test. The reflected radiation is directed through a channel common to both reflected beams and applied to a photo-multiplier cell. Polarizing plates or filters in the path of the reflected radiation are adjustable to regulate the normal light level to correspond to the sensitivity of the photo-multiplier pick up cell.

This system, employing a dual light source for detecting cracks or crizzles, is found to be far superior to systems in which a single light source or head is employed and particularly in respect to the setting up, adjusting, and detecting. This superiority is found in the provision of a much higher degree of light concentration on the surface under inspection, such as the sealing surface of a bottle or jar finish, thereby enabling detection of a comparatively great variety of defects such as crizzles, checks, etc. Further, the invention provides means by which the normal light level can be controlled to operate the photo-multiplier tube within the range of its greatest sensitivity level.

Moreover, the use of the photo-multiplier pick up as a means of detecting such defects is found to be greatly superior to the use of a photo tube such as employed in prior art devices. The photomultiplier tube amplification factor is far greater than with such photo tubes and also has much greater stability.

There were 9 claims and the following references cited in this patent.

United States Patents

2,219,572, Everett, Oct. 29, 1940; 2,472,945, Gingrich, June 14, 1949; and 2,481,863, Owens, Sept. 13, 1949.

Glass tempering apparatus. Patent No. 2,876,593. Filed September 28, 1954. Issued March 10, 1959. No sheets of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Martin W. Neuhausen.

This invention pertains to apparatus for tempering glass and, more specifically, to apparatus which imposes an even temper upon a curved glass sheet.

The apparatus combines two movements in mutually perpendicular planes to produce overlapping circular patterns of air blast upon a curved glass sheet disposed intermediate the air blast nozzles. This result is obtained by bodily moving the entire apparatus back and forth in a straight line upon tracks, while the air blast nozzles are oscillated at right angles to the path of movement of the frame and along a path conforming to the contour of the bent glass sheet independently supported within the frame. When the glass sheet is substantially flat and the path of movement of the air nozzle is parallel to the plane of the glass sheet, the same overlapping circular patterns are formed by the air blast upon the flat sheet.

Air boxes at opposite sides of the glass are set to move in unison relative to the glass. With this arrangement, each individual air blast nozzle is opposed by an opposite member in its path of movement relative to the sheet. Such a precaution enables more uniform cooling of the glass.

Another object of the invention is to provide tempering apparatus which comprises blast nozzles for imparting a uniform blast of tempering fluid substantially normally to the sheet wherein the blast nozzles are maintained a substantially uniform distance from the sheet.

There were 13 claims and 12 references cited in this patent.

Feeding and Forming

Nacreous material from glass. Patent No. 2,863,783. Filed November 15, 1956. Issued December 9, 1958. No sheets of drawings; none reproduced. Assigned to Francis Earle Laboratories, Inc. by Leon M. Greenstein.

By the formation of the glass particles it has been demonstrated that the nacreous effect can be obtained without the use of crystalline materials, so long as the individual particles are sufficiently thin platelets with a suitable index of refraction. Various glass compositions were converted into lamellae of dimensions similar to those of the nacreous crystals. When incorporated into a vehicle, these glass platelets have a pearly luster like that of the known nacreous pigments. The usual pearly effects were obtained both by coating surfaces with these platelets and also by incorporating the platelets in transparent plastic compositions.

A convenient method for forming the flakes involves first blowing extremely thin films of the appropriate glass. The film thickness should be 2 microns or less and is of the correct order of magnitude if the films show interference colors.

To convert the film to platelets, it is suspended in water or other liquid, and agitated violently, or ground in any suitable device, such as a ball mill. Samples are withdrawn from the suspension at frequent intervals (perhaps only 30 seconds apart) and examined by the microscope to determine the size of the fractured particles.

The process is stopped when the glass film has been reduced to platelets whose long dimension falls preferably between 2 and 100 microns. Although lengths of 2 to 100

microns produce optimum luster, lamellae which are even smaller than 2 microns in length are suitable if the particles are thin enough.

The resulting suspension of glass platelets has the typically silky appearance of nacreous suspensions. If desired, the lamellae can be fractionated into more uniform size ranges by settling and decantation or by centrifuging.

A glass consisting of 90.8 per cent Sb_2O_3 and 9.2 per cent B_2O_3, ($n_D = 1.95$), was also blown and fractured using styrene as the grinding liquid.

Glass lamellae are prepared in accordance with a glass of the composition:

20.1 per cent SiO_2
29.5 per cent Na_2O
50.4 per cent TiO_2

where $n_D = 1.80$.

There were 14 claims and the following references cited in this patent.

United States Patents

2,266,638, Hauser, Dec. 16, 1941; 2,308,409, Wenzel, Jan. 12, 1943; 2,363,570, Caprio, Nov. 28, 1944; 2,597,562, Blodgett, May 20, 1952; and 2,601,123, Moulton, June 17, 1952.

Vacuum settle and counterblow apparatus for bottle making machines. Patent No. 2,826,867. Filed July 18, 1955. Issued March 18, 1958. No sheets of drawings; none reproduced. Assigned to Brockway Glass Company, Inc., by John O. Nava, Jr., Angelo J. Buffone, and Kenneth Grinnen.

The present invention relates generally to glass bottle or glass container manufacturing machines of the general type wherein a glass parison or preform is first produced, then subsequently blown to final shape in a finished mold.

Initially the air pressure for forcing the glass downwardly into an inverted parison mold to insure filling of the neck ring mold portion thereof was accomplished by positive air pressure introduced from above. This necessitated a certain time delay for bringing the air pressure means into position at the top of the parison mold and for subsequently moving it out of position ant replacing it with a top closure for the mold. Subsequently it has been proposed to produce this charge settling force by a subatmospheric pressure at the lower portion of the charge to draw the glass down into the neck ring to fully fill the latter prior to counterblowing. This latter procedure is referred to in the art as suction or vacuum settle.

The present invention provides novel apparatus of this general type wherein the vacuum settle pressure is introduced and applied in a novel manner and wherein the apparatus is greatly simplified by employing a common central axial passage upwardly through the mechanism below the neck ring for conducting both the subatmospheric vacuum settle pressure and, subsequently, the super-atmospheric counterblowing pressure.

The invention thus reduces settle waves to a new and significant minimum by reducing the over-all time from the time when the charge is delivered to the parison mold to the time when counterblowing pressure may be applied.

This reduction in the time cycle is effected both by reason of the manner in which the pressure is actually applied and by reason of the simplification of the mechanism itself so that more rapid mechanical operation of the plunger and needle mechanisms is feasible.

There were 4 claims and the following references cited in this patent.

United States Patents

1,911,119, Ingle, May 23, 1933; 2,129,614, Bridges, Sept. 6, 1938; and 2,466,669, Winder, Apr. 12, 1949.

Furnaces

Electrodes for glass melting furnaces. Patent No. 2,843,644. Filed September 5, 1956. Issued July 15, 1958. No sheets of drawings; none reproduced. Assigned to Elemelt Limited by Douglas Graeme Hann.

An electrode for a glass melting or refining furnace comprises an electrode body and a supporting stem projecting therefrom. The electrode body is made of molybdenum, tungsten or other refractory and electrically conductive material selected in relation to its ability to withstand immersion in the molten glass. The stem is made of steel or other material selected in relation to its ability to withstand exposure to the atmosphere at the operating temperature without destructive oxidation or corrosion. The inner end portion of the stem is protected from the destructive effect of immersion in the molten glass by a socket part of molybdenum, tungsten, or one of said refractory materials, in which the inner end portion of the stem is received. The stem has an internal axially extending passageway for the flow of cooling liquid and for the accommodation of an axially extending conductor member for conveying current to the electrode body independently of the current (if any) conveyed by the stem. The stem has an end cap at its inner end which prevents contact between the liquid and the electrode body and socket part so that the existence of molybdenum-steel, or tungsten-steel, or other corrosion-prone load carrying junctions in the presence of the liquid are avoided, the passageway for the cooling liquid extending near enough to the inner end of the stem and the latter having sufficient thermal communication with the electrode body for the cooling liquid to be effective to cool the electrode body as well as the stem and prevent mechanical failure of these under operating conditions.

There were 15 claims and the following references cited in this patent.

United States Patents

961,139, Keller, June 14, 1910; 1,542,716, Payne, June 6, 1929; 1,880,540, Wadman, Oct. 4, 1932; 2,209,515, Ehman et al., July 30, 1940; 2,594,972, Muehlenkamp, Apr. 29, 1952; and 2,594,973, Muehlenkamp, Apr. 29, 1952.

Glass Compositions

High-index glass elements. Patent No. 2,842,446. Filed December 27, 1954. Issued July 8, 1958. No sheets of drawings; none reproduced. Assigned to Minnesota Mining & Manufacturing Company by Warren R. Beck and Nelson W. Taylor.

The invention relates to new and useful, transparent

(*Continued on page 448*)

Research Digest

Experimental Method for Developing Minute Flaw Patterns in Glass

• THE EXISTENCE OF minute crack patterns in glass was postulated by Griffith in 1927; since this time there have been numerous theoretical discussions regarding the dimensional properties of these cracks, as well as their probable effect on strength. Experimental investigations on the formation mechanisms and physical characteristics of these flaws is quite another story. Here most of the work has been of an indirect nature. In 1937 Andrade and Tsien did, however, provide the first evidence that very minute defects were present in glass. The crack patterns were developed by heating glass in an evacuated chamber containing pure sodium. This treatment produces a network of fine lines which meet each other at approximately 90 degrees but do not appear to cross. They found that used or abraded surfaces contained a greater number of lines than pristine glass.

Similar flaws were also studied by Levengood and Butler using a glue adherence technique as well as the sodium vapor method. It was found that the frequence of cracks and the glue adherence force were proportional to the residual stress in the glass. By considering a cooling glass sphere, a theory was developed which was in agreement with the experimental observations.

It was recently discovered that these minute flaw patterns could be developed by using an etching technique. The method is based on the slow action of dissociated sodium fluoride on glass surfaces. W. C. Levengood in the March, 1959, issue of the *Journal of Applied Physics* describes this new flaw-developing method and presents various findings from the initial experiments. Results indicate that the process will be useful in studies of various surface and strength problems in glass.

The manner in which these flaw patterns could be influenced by localized stress fields as well as their reaction in the etching solution was highly suggestive of dislocation mechanisms usually observed in crystalline materials.

The method used to bring out these flaws was found to be extremely sensitive to fingerprints and other forms of surface contamination on glass. A cleaning procedure was generally used except when samples were newly made and had not been handled. The cleaning consisted of rubbing the surface with absorbent cotton saturated with a mud of precipitated calcium carbonate. The sample was then rinsed in tap water followed by distilled and the glass was thoroughly dried by rubbing with absorbent tissue in a random motion.

After drying, the samples were immediately placed in a solution consisting of the following composition: 2 parts 10% NaF, 1 part 10% HCl. The optimum etching time for soda-lime-silica type glasses was found to be about 15 minutes. After treating, the sample was rinsed to remove the excess loose crystalline deposit and reaction products.

The experiments with the etching technique indicate that the minute flaw patterns in glass react differently in the etching solution than ordinary cracks and fractures. It should be mentioned that there is a possibility that the etching process may create surface forces which nucleate flaw formation. However, the fact that such effects as repetition of patterns, orientation, association with mechanical forces, matching of cleavage surfaces, etc., were shown makes this possibility seem far less likely than when using other techniques, such as the sodium vapor method. At least in the majority of cases the etching method appears to show existing flaw patterns.

The formation of flaws at aged crack tips is very similar to the action of dislocations in crystals. The presence of dislocations in LiF crystals was found by Gilman, Knudsen, and Walsh to block the spreading of a crack and decrease the average crack velocity. The formation of the flaw at the crack tip in glass may account for the resistance to crack spreading or the strength increase recently observed by Levengood. This strengthening effect was observed in glass samples which had visible internal cracks as well as in samples which were cyclically fatigued.

In the various studies aforementioned, the effects are believed to occur around cracks which are produced within the body of the material. When a crack is formed near the surface of glass and extends laterally, it discloses considerable movement over a period of time. The propagation of this type of flaw appears to be in disagreement with the above suggestion that flaws at the crack tip inhibit growth.

The kinetics of these slow fractures were recently studied and it was found that external atmosphere as well as internal gases in the glass affect the rate of fracture propagation. The penetration of the external atmosphere in this type of flaw may create a stress which keeps the fracture moving and does not allow the formation of these minute flaws at the tip. The external atmosphere apparently does not penetrate the cracks in the body of the glass and produce the stresses necessary to cause the crack to spread. The slow fractures on the surface have only to "push up" a thin layer (approximately 0.1 mm thick) of glass whereas those in the body of the glass must spread against the inertia of the bulk material.

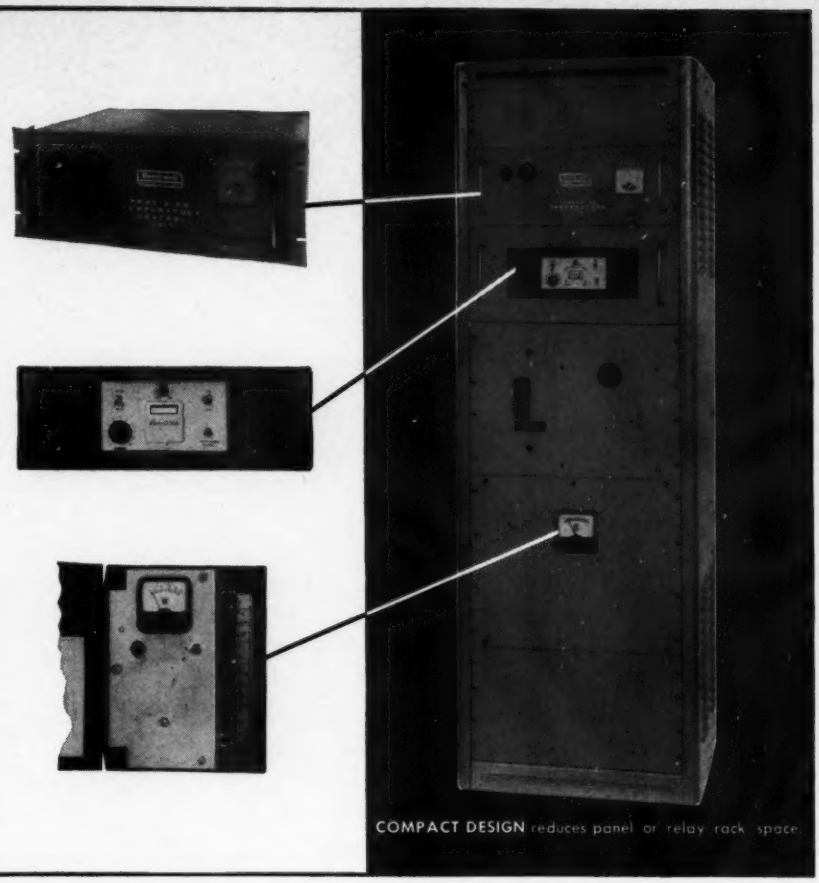
Even though we have discussed the effect of these minute crack tip flaws on different types of fracture propagations, it is still questionable whether they should be considered dislocations in the glass structure. Disloca-

(*Continued on page* 446)

PRECISION TEMPERATURE CONTROLLER, Series 2HCT-3, has no moving parts. No stray electrical pickup . . . free from drift . . . continuous automatic standardization. Available in wide variety of ranges for any thermocouple input.

***ELECTR-O-VOLT* CURRENT OUTPUT PROPORTIONING CONTROL UNIT** has graduated proportional band dial, graduated reset rate dial, graduated approach rate dial, manual-automatic switch, manual control dial and power switch.

BROWN MAGNETIC AMPLIFIERS feature bias adjustment for full control rangeability, auxiliary control windings for feedback control systems, fused safety circuit, easily accessible terminal behind hinged door cover. The power input dial pointer is the only moving part. Two models available for loads up to 100 KVA.



COMPACT DESIGN reduces panel or relay rack space

Precision Package for Glass Fiber Bushing Control

. . . controls temperature within 0.25 degree at 2000°F

Combined in a single compact unit, this temperature controller, power proportioning control unit and magnetic amplifier give "right-on-the-nose" results with saturable core reactor furnaces whose temperature can be measured with thermocouples.

The Precision Temperature Controller consists of a null balance input circuit with manually adjusted set point and a highly stable d-c amplifier. The difference between the thermocouple signal and set point is amplified 100,000 times to provide the required sensitivity. Three-digit vernier set knob readable to one part in 2000 of a 1000°F. span.

The *Electr-O-Volt* power proportioning control unit provides a continuously variable control input to the Brown Magnetic Amplifier. It gives true non-interacting proportional-plus-reset, plus rate control action which adjusts heat input to compensate for the size of load, ambient temperature and other variations in heat demand.

The Brown Magnetic Amplifier receives its signal from the *Electr-O-Volt* unit and amplifies it for transmission to the control windings of the saturable core reactor . . . to provide stepless, contactless, highly accurate furnace control.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

First in Control

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during May, 1959, was as follows: *Flat Glass:* a preliminary figure of 29,500 for May, 1959, indicates a decrease of 1.0 per cent under the adjusted figure of 29,800 reported for April, 1959. *Glass and Glassware, Pressed and Blown:* an increase of 2.4 per cent is shown by the preliminary figure of 85,800 reported for May, 1959, when compared with the adjusted figure of 83,800 reported for April, 1959. *Glass Products Made of Purchased Glass:* the preliminary figure of 14,200 given for May, 1959, is a decrease of 4.2 per cent under the adjusted figure of 14,820 reported for April, 1959.

Payrolls in the glass industry during May, 1959, were as follows: *Flat Glass:* a decrease of 1.8 per cent is shown in the preliminary $16,734,652.62 given for May, 1959, when compared with April's adjusted $17,040,415.10. *Glass and Glassware, Pressed and Blown:* An increase of 2.3 per cent is shown in the preliminary $33,013,300.32 reported for May, 1959, when compared with the previous month's adjusted $32,243,759.52. *Glass Products Made of Purchased Glass:* a preliminary figure of $4,557,423.40 was reported for May, 1959. This is a decrease of 4.4 per cent when compared with the adjusted figure of $4,767,305.26 for April, 1959.

Glass Container production: production based on figures released by the Bureau of the Census, Industry Division, was 13,713,000 gross during June, 1959. This is an increase of 2.6 per cent over the previous month's revised production figure of 13,354,000 gross. During June, 1958, glass container production was 12,711,000 gross, or 7.3 per cent under the June, 1959, figure. At the end of the first six months of 1959, glass container manufacturers have produced a preliminary total of 75,731,000 gross. This is 7.2 per cent more than the 70,595,000 gross produced during the same period in 1958.

Glass container shipments: Shipments of glass containers during June, 1959, came to 13,770,000 gross, an increase of 2.3 per cent over May, 1959. Shipments during June, 1958, amounted to 12,329,000 gross, or 10.0 per cent less than June, 1959. At the end of the first six months of 1959, shipments have reached a preliminary total of 73,674,000 gross, which is 7.0 per cent more than the 68,539,000 gross shipped during the same period the previous year.

Stocks on hand at the end of June, 1959, came to 19,774,000 gross. This is 0.3 per cent less than the 19,832,000 gross on hand at the end of May, 1959, and 3.7 per cent more than the 19,101,000 gross on hand at the end of June, 1958.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	June, 1959
Food	1,316,000[2]
Medicinal and Health Supplies	1,304,000[2]
Chemical, Household and Industrial	1,003,000
Toiletries and Cosmetics	875,000
Beverage, Returnable	1,401,000
Beverage, Non-returnable	157,000
Beer, Returnable	425,000
Beer, Non-returnable	1,007,000
Liquor	877,000
Wine	420,000[2]
Sub-total (Narrow)	8,785,000

Wide Mouth Containers

Food	*3,806,000
Medicinal and Health Supplies	394,000
Chemical, Household and Industrial	145,000
Toiletries and Cosmetics	264,000
Packers' Tumblers	44,000[2]
Dairy Products	147,000
Sub-total (Wide)	*4,800,000
Total Domestic	13,585,000
Export Shipments	185,000
TOTAL SHIPMENTS	13,770,000

*This figure includes Fruit Jars and Jelly Glasses.

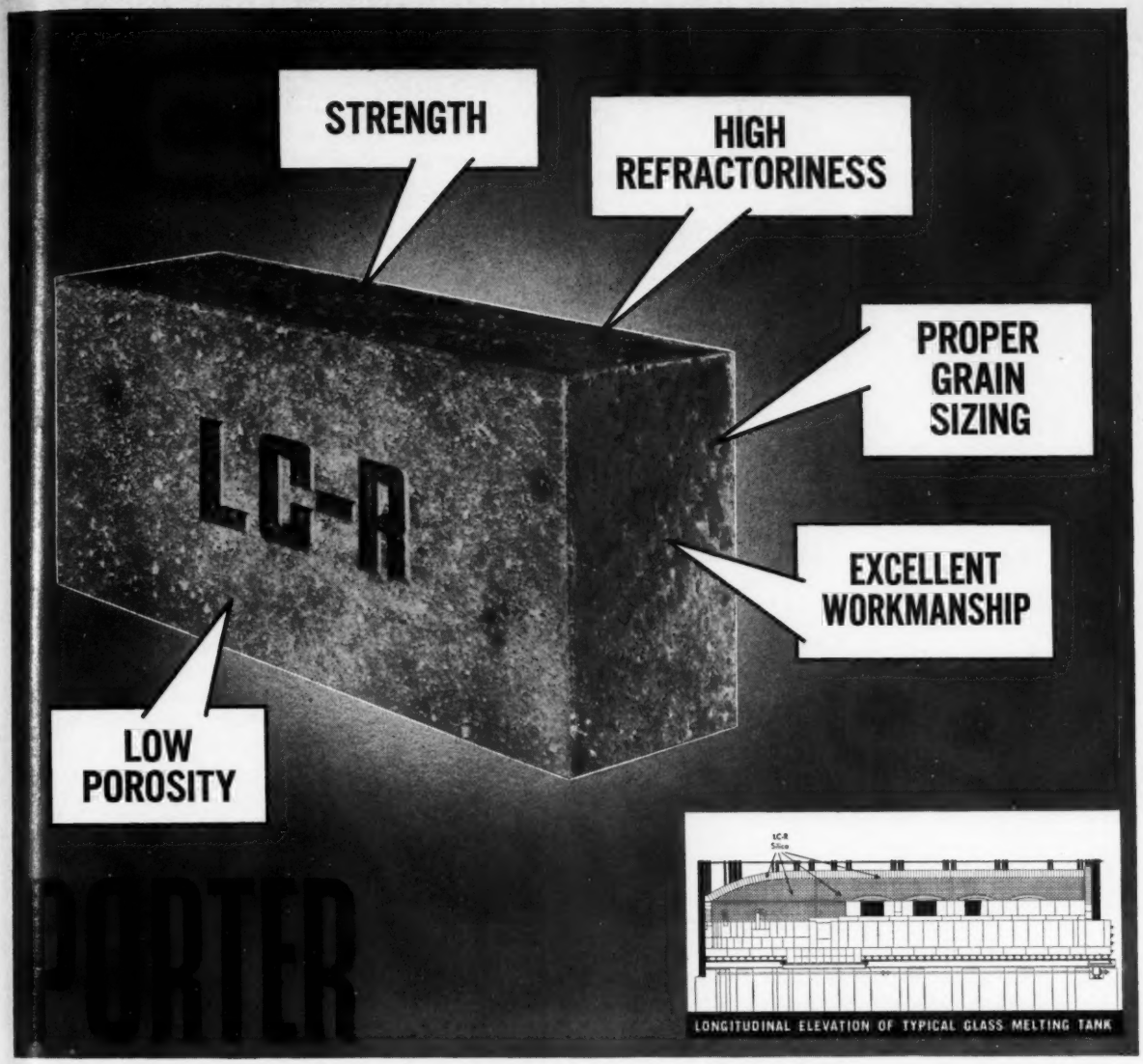
GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production June 1959	Stocks June 1959
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics	Narrow Neck	4,720,000[2]	6,930,000[2]
	Wide Mouth	*4,767,000[2]	*6,972,000
Beverage, Returnable		1,117,000	1,827,000
Beverage, Non-returnable		185,000	241,000
Beer, Returnable		434,000	475,000
Beer, Non-returnable		92,000	855,000
Liquor		960,000	1,315,000
Wine		387,000[2]	739,000[2]
Packers' Tumblers		41,000[2]	111,000[2]
Dairy Products		120,000	309,000
TOTAL		*13,713,000	*19,774,000

*This figure includes Fruit Jars and Jelly Glasses.

[2] Includes quantities for 1 plant not previously reported.
[3] Includes quantities for 2 plants not previously reported.



brings you a super-duty **SILICA** brick for stronger, longer service tank crowns

More than twenty major glass producers now have found the answer to their crown problems . . . found it in Porter's Super-Duty LC-R Silica brick. Another 100° F. additional temperature (actual test averages) can be poured on, and still run *longer* campaigns with a solid, secure crown.

These uniform, strong brick give you the best possible Silica for any glass melting tank *because of their 5 key qualities . . .* strength, High Refractoriness, Low Porosity, Proper Grain Size, Excellent Workmanship.

LC-R Brick will fit your plans for higher rates of pull and longer campaigns.

Write: Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pa.

REFRACTORIES DIVISION **PORTER** **H.K. PORTER COMPANY, INC.**

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

New Equipment and Supplies

Rotary Vibrator Screen

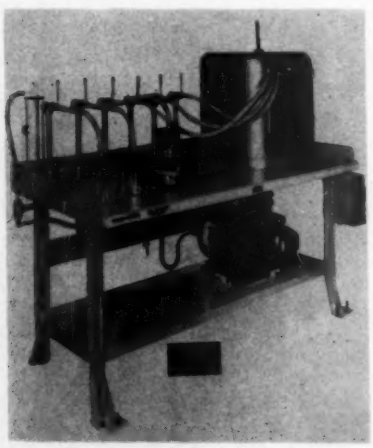
Syntron Co., Homer City, Pa., has developed a new electromechanical rotary vibrator screen the RVS-146, which handles dry or wet screenings of sand, gravel, clay, chemicals, food products, and other bulk materials in sizes ranging from 100 mesh to three-inch lumps.

The unit is available with single or double deck screening areas, 4 x 6 feet, and can be equipped with either a 900 or 1800 rpm drive. Fitted with dust-tight covers, it has pneumatic vibration-absorbing mounting members to prevent transmission of vibration to the building structure or adjoining equipment. The vibrator operates on 220 or 440 volt, 3-phase, 60-cycle alternating current.

Small Glass Case Cleaner

Kahle Engineering Co., Union City, N.J., has a glass case cleaner, number 3077, for small glass cases like those used in the diodes of electronic tubes. Cleaning capacity is several thousand parts per hour.

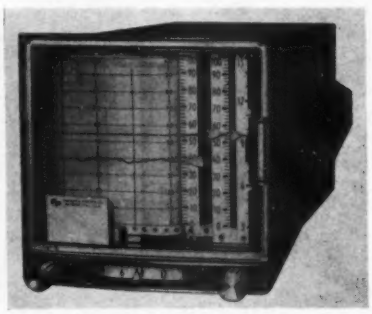
The unit is 5′ long, 3′ wide.



Strip Chart Recorder

Fischer & Porter Co., Hatboro, Pa. has modified its Mark III four-inch strip chart recorder. A new inking system is featured that provides a month-long record without refill and a bolder, more uniform line over the entire chart width, enabling reinking without interfering with movement of pen parts.

Other new features include a flip switch for reversing controller action from air-to-open to air-to-close, built-in damping of pneumatic input signals, fused chart motor, and easier-to-read scales with larger high-intensity colored pointers.



Glass Pipe

Kimble Glass Co., subsidiary of Owens-Illinois Glass Co., Toledo, O., has developed a line of tempered industrial glass pipe and fittings which, the company says, allows operations up to 450° F., with maximum, sudden temperature differentials ranging up to 210° F. Called Kimax, it is interworkable and interchangeable with other tempered hard glass transmission systems having the same linear coefficient of expansion of 32x10-7/°C (0-300°C).

Electronic Tube Stems

The Electronics Division of Diamond Power Specialty Corp., Lancaster, O., is manufacturing stem components for electron tube construction in 8, 9, and 14 pin configurations. The conductors are Kovar metal sealed for high vacuum in 7052 borosilicate glass. The pins are hydrogen fired prior to assembly to occlude residual glasses, and the entire assembly is annealed

and descaled following completion of construction. All sizes have provision for vacuum tabulation; stems are individually wrapped and packaged.

Pneumatic Vibrator

Cleveland Vibrator Co., Cleveland, O., has a new pneumatic vibrator delivering 16,000 pounds of impact. The 7″ model FAC operates on 60-80 pounds of air pressure, and the 175-pound piston has a 1¼″ stroke. Reciprocating action of the piston is air cushioned for quiet operation on applications where noise is an objectionable factor. Weight: 539 pounds.

Bottle Crusher

Rescor Industries, Mount Vernon, N.Y., has announced a large size bottle breaker, Model No. 1000, for use on vials or gallon jugs. The hopper is self-closing and the impeller is made of manganese moly type steel.

The unit is shipped with a 55-gallon steel drum and has an adapter for use on a No. 2 can.

Fiberglas Packaging Material

Owens-Corning Fiberglas Corp., Toledo, O., has a Fiberglas packaging material to protect a wide variety of objects from damage and rapid changes of temperature in transit. This material retains the following characteristics in temperatures from −120° to 375°F: high compression resistance, damping and thermal efficiency, extreme resilience, fire retardance, noncorrosiveness and resistance to fungus and rot. The material conforms to all requirements of Military Specifications Mil-C-7769; it is available in lengths up to 96", widths 1-72" and thicknesses of ¼ increments.

Automatic Recorder Changer

Maeder-Squier Co., Dallas, Tex., has developed the Automatic Meterman, a device for automatically changing circular recording charts. It is said to utilize as many as 40 circular charts in a single recorder and disengage them one by one, at any desired time, date or frequency, with a gravity drop into a self-contained storage box.

Vise Mounted Vibrator

Cleveland Vibrator Co., Cleveland, O., has a new vise-lock mounting for

its RC-5 electric vibrator. The vise has a 2½" jaw opening in a U-shaped head that grips wooden studs and iron or steel structures. Mounting and vibrator weigh 39 pounds. The vibrator operates at 3-phase, 60-cycle current from 110 to 550 volts.

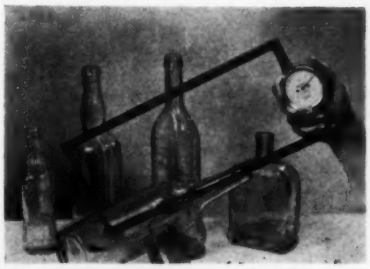
Amino-Silane Chemical

Dow-Corning Corp., Midland, Mich., has an amino-silane chemical, Dow-Corning Z-6020, which reacts with both organic and inorganic materials to unite them in a strong, durable bond. The company states that glass or mineral wool insulation has greater resiliency, heat stability and resistance to damaging effects of moisture when the silane is added to binder resins. Glass fibers pretreated with a dilute solution of the silane can be dyed with a variety of standard wool dyes.

Wall Thickness Micrometer

Testing Machines, Mineola, N.Y., has announced a device for measuring the wall thickness of stock and special glass bottles.

The apparatus can take measurements up to a distance of 325 mm. from the mouth and can be inserted in openings as small as 13 mm. A smaller model is available for openings smaller than 13 mm.



CATALOGS RECEIVED

Pointer and indicator gages. (specification sheets) Covers specifications and data of The Hays Model 211, 212, and 213 pointer gages and model 214 vertical scale indicator.

HAYS CORP., Michigan City, Ind.

Vycor silica glass. (8 pages) Bulletin B-91 describes physical properties, ultraviolet and infrared transmittance characteristics, and optical grades of Vycor brand 96 per cent silica glass. Properties of 10 Vycor brand glass compositions are outlined. Charts, tables and product photographs.

CORNING GLASS WORKS, Corning, N. Y.

Cleaning industrial floors. Charts and lists of cleaning compounds. Methods of cleaning, sanitizing, stripping wax and paint and absorbing liquids.

OAKITE PRODUCTS, INC., New York, N. Y.

Laboratory apparatus. (1568 pages) Illustrations, tables and charts of laboratory apparatus: instruments, appliances, standard glassware, "Inter-Joint" glassware and general supplies.

SCIENTIFIC GLASS APPARATUS, CO., INC., Bloomfield, N. J.

Selector station. (4 pages) Description of 32 standard types of selector stations to adjust remote manual trimming of pneumatic control systems and transfer operation from automatic to manual. Classified according to application.

BAILEY METER CO., Cleveland, Ohio

Industrial truck. (18 pages) Describes major features of construction and operating characteristics of the battery-powered industrial truck.

ELECTRIC INDUSTRIAL TRUCK & ALLIED PROD., Pittsburgh, Pa.

Brown magnetic amplifier. (2 pages) Specifications, operation and function of the amplifier as a stepless, contactless means of electric furnace temperature control. Dimensions, schematic and operating diagrams.

MINNEAPOLIS-HONEYWELL REGULATOR CO., Philadelphia, Pa.

Unitair compressors. (16 pages) Specifications for eight air-cooled compressors in the 15 to 125 h.p., 81 to 641 C.F.M. range. Cross section drawings.

JOY MFG. CO., Pittsburgh, Pa.

Heavy duty compressors. (12 pages) Specification and dimensions of WN-224 semi-radial design compressors in six basic models ranging from 350 to 1,250 h.p. and 2418 to 7392 C.F.M. Cross section drawing and installation photographs.

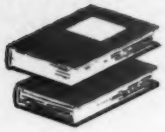
JOY MFG. CO., Pittsburgh, Pa.

Insulating materials. (14 pages) Fiberfrax insulating materials with melting point above 3,200°F. and each of 14 forms in which the material is manufactured.

CARBORUNDUM CO., Niagara Falls, N. Y.

Processing glass. (20 pages) Description of Selas Gradiation Heating with photographs, schematics and charts of installations that successfully solved various glass heating problems such as melting, annealing, fire-polishing, bending, tempering, coating, fiberizing and processing for electronics.

SELAS CORP. OF AMERICA, Dresher, Pa.



NEW BOOKS

1958 Book of ASTM Standards (1959); American Society for Testing Materials, Philadelphia, Pa.; 10 parts.

The number of parts in this text was increased from 7 to 10 in 1958 because of the growth in size in the individual volumes to the point where they could no longer be bound economically and were becoming unwieldy.

Total content of the 10 parts is 2,450 standard specifications, methods of test, definitions of terms, and recommended practices, occupying 13,600 pages. Each part is complete with a detailed subject index and a list of standards in numerical sequence. Supplements will be issued to each section in late this year and in 1960. A complete index is furnished without charge with each set of the Book of ASTM Standards.

A brief description of each part is included below, with emphasis on those sections of special interest to the glass manufacturing industry.

Part 1. Ferrous Metals Specifications (except test methods), 1620 pages; 291 standards. $12.

Steel (both carbon and alloy); Zinc- and lead-coated steel articles; wrought iron; cast iron; malleable iron; ferro-alloys; and metal powder products.

Part 2. Non-Ferrous Metals Specifications (except test methods), Electronic Materials; 1380 pages; 251 standards. $10.

Aluminum and aluminum-base alloys; magnesium and magnesium alloys; zinc and zinc alloys; copper and copper alloy castings; lead and lead alloys; nickel and nickel alloys; lead- and tin-base alloys; titanium; electrical heating and resistance alloys; metal powder products; electrodeposited coatings; electrical contact materials; materials for electron tubes, electronic devices and lamps.

Part 3. Metals Test Methods (except chemical analysis); 992 pages; 121 standards. $10.

Metallography; tension; compression; bending; hardness; impact; magnetic particle testing; hardenability; grain size, creep, radiographic standards; linear expansion; inclusion content; heat treatment; thermal analysis; corrosion; weight, thickness and uniformity of coatings; verification of testing machines; electrical and magnetic properties of metals; density; particle size; sampling; ultrasonic testing.

Part 4. Cement, Concrete, Mortars, Road Materials, Waterproofing, Soils; 1456 pages; 338 standards. $12.

Part 5. Masonry Products, Ceramics, Thermal Insulation, Sandwich and Building Constructions, Acoustical Materials, Fire Tests; 1142 pages; 210 standards. $12.

Asbestos-cement products; brick; structural tile and filter block; thermal insulation; refractories, fire brick; ceramic whiteware; porcelain enamel; glass and glass products.

Part 6. Wood, Paper, Adhesives, Shipping Containers, Cellulose, Leather; 1040 pages; 219 standards. $10.

Part 7. Petroleum Products, Lubricants, Tank Measurements, Engine Tests; 1516 pages; 260 standards. $12.

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Cost of complete set: $116.

Impact Tests of Full-Tempered Glass Windshield Panels. (CAA Technical Development Report 71; 6 pages; 50 cents.

Order PB 151347 from OTS, U.S. Department of Commerce, Washington 25, D.C.

Full-tempered glass panels from ¼ to 1¼-inch thicknesses were tested for impact and optical deviation. An experimental relationship was found between the penetration velocity and the panel thickness. At impact velocities less than that required for failure, no effect upon the full-tempered pane was observed. At impact velocities which result in panel failure, the energy-absorption factor of the full-tempered glass was relatively low. The penetration velocity of these panels was independent of panel temperature. The full-tempered glass panes showed excellent optical charactistics. From weight considerations, the practical application of full-tempered glass panels for aircraft use appears to be limited to low-speed aircraft, windshield installations with a high angle of panel slope, and particularly for side- or corner-window installations of high slope.

Profit Sanctuaries and How They Are Used (1959 Edition). Business International, New York; 72 pages; $24.

A study describing how American companies are accumulating capital for investment abroad by headquartering their foreign operations in countries which impose little or no tax on income arising from sources outside their borders. The report analyzes the advantages and disadvantages of "profit sanctuary" operations and makes clear that they are established to defer, not to avoid, United States taxation.

Numerous case histories are included, showing how individual firms have used "profit sanctuary" subsidiaries. One chapter discusses HR 5, now before Congress, which would defer U. S. taxation of foreign-earned income until profits are remitted to the U. S. parent company.

Ream in Flat Glass
(*Continued from page* 419)

Case History No. 2

In 1955 due to the malfunction of a supervisor while the soda ash scales were being repaired, an unknown number of batches which contained no soda ash were charged into the furnace. Approximately 24 hours of production was scrapped because of ream and stones. (Incidentally, the color slides shown previously were of this vintage.)

Case History No. 3

During the furnace campaign which ended in 1954, frequent mechanical failures of the batch conveying system caused the batch bins above the furnace to run empty. In such cases, emergency batch was used which had been stored in a reserve bin remote from the furnace. Too often to be considered coincidental, intermittent scrap due to ream resulted. Segregation of the materials in the reserve batch bin was generally accepted to be the cause of the ream trouble.

Case History No. 4

In 1949, concurrent with the filling of a new furnace, the glass composition was significantly changed. After the usual starting difficulties were ironed out, we found ourselves in serious ream trouble which we could not cure. We were using a salt-cake-to-carbon ratio of 15 to 1. Within 24 hours after changing the ratio from 15-to-1 to 20-to-1 the ream condition started to clear up and continued to do so until satisfactory operation was obtained.

Case History No. 5

During 1948, frequent, prolonged epidemics of ream were experienced concurrent with attempts to increase the production rate of the furnace. Any significant change in temperature level, temperature distribution, or production rate would result in heavy scrap due to ream. When the furnace was drained, it was found that more than 50 per cent of the total weight of glass in the furnace was significantly different from that which had been manufactured during the 30 days prior to draining the furnace.

Case History No. 6

In 1946 toward the completion of a sheet-glass batch change of considerable magnitude, wherein, a heavy glass was changed to one of lighter density, the writer observed a severe ream epidemic occur on each of two adjacent furnaces, but separated by one week. In both cases the trouble was caused by a significant increase in melting-end temperatures which affected a "boil up" of the original heavy glass from stagnant areas within the furnaces.

Case History No. 7

Because of a relation between the canal glass temperature and bubbles, it is our custom to use water-cooled, hairpin-shaped, cooler bars in the refining-end when

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needed. These bars are usually positioned at right angles to the length of the furnace and about one foot above the glass. In 1955 under certain conditions of glass temperature, production rate, etc., when larger bars were inserted into the plate glass furnace, it was not uncommon to observe two dark lines form in the glass parallel to the length of the furnace and separated by a distance approximately equal to the width of the canal. These lines would appear to be several inches in width and would extend from the canal entrance to a position as much as 20 feet upstream.

Later in the furnace campaign the appearance of the dark lines became a cue for heavy localized ream to appear in the same relative location in the glass ribbon. Under these conditions, if the coolers were removed, the dark lines would immediately disappear and after a reasonable time delay, the ream would disappear from the ribbon. The most logical explanation of the phenomena was that concurrent with the excessive cooling, an equilibrium between the channelized movement of glass toward the canal, sidewise movement of glass to the furnace sidewall, and surface tension, would establish itself and cause colder, sub-surface glass to come to the surface which would result in ream. (This explanation would probably break down under cross examination.)

Case History No. 8

For a period of approximately four months in 1952 we were plagued with a sharp localized ream which resembled a cord. It would appear in the ribbon and after a few minutes disappear only to reappear in a different position a short time later. After exhaustive (and exhausting) attempts to find the cause, it was conclusively established that the ream was pulling off a specific refractory shape at the canal entrance. By cooling the glass in that specific area, the trouble was eliminated.

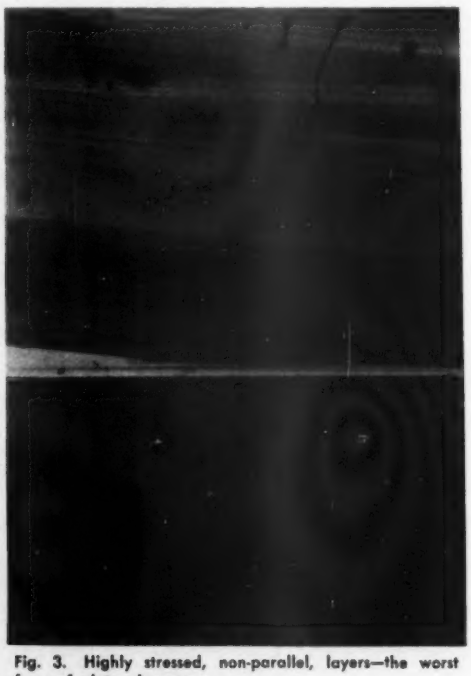


Fig. 3. Highly stressed, non-parallel, layers—the worst form of plate glass ream.

In attempting to formulate a general statement for the cause of ream, it would be appropriate to classify the specific reasons for ream in each of the case histories just presented. The general classifications are:

1. Raw material quality.
2. Scale errors.
3. Segregation.
4. Incorrect formulation of batch.
5. Changes in furnace operating conditions.
6. Stagnant glass in furnace.
7. Surface tension and/or convection currents.
8. Refractory wash.

It is believed that the preceding facts are sufficient to justify the following generalization:

Because a severe off-standard condition of any one of the eight general classifications is sufficient to produce a severe ream epidemic, a slight off-standard situation of one, or a combination of more than one, of the eight classifications (or of the probable eight-eight conditions which were not mentioned) should be sufficient to cause, at least, "non-homogeneous layers in flat glass." If this statement is true, then in order to produce large quantities of truly homogeneous glass, all significant conditions must be maintained at their optimum values. This constitutes a pretty tough assignment.

Probably, there are at least a few people in the glass industry, who still believe that you can put almost anything in a glass-melting furnace and still make good glass, providing you "burn out the variables." Recent tracer tests which were conducted on both plate and sheet glass furnaces at our company indicate quite the contrary. The plate glass furnace was producing glass at the rate of 192 tons per day at a ratio of 5.65 sq. ft. of melting area per ton of glass per day. The tracer material was mixed with the batch and introduced into the furnace for a one-hour period. It first appeared in the ribbon five hours after its entry into the furnace, and even after 48 hours was still very much evident in the glass as "non-homogeneous layers." (Incidentally, the glass possessing the greatest degree of homogeneity the writer has ever observed from this furnace has been the initial production after a long period of downtime during which the heat was held slightly below operating level.)

The sheet glass furnace was producing glass at the rate of 130 tons per day at a ratio of 12.7 sq. ft. of melting area per ton of glass when a similar test was conducted. The tracer was introduced in to the furnace for a 25-minute period. Only after 48 hours was the tracer well diffused within the glass. These tracer tests substantiate our previous generalization.

When I talked to this same group in 1954, I reported that approximately 40 per cent of the total dollar scrap loss for the plate glass furnace campaign completed in that year was due to ream. In an effort to improve production quantity and quality, and furnace life, when that furnace was rebuilt, the following changes were made:

1. The total furnace port area was reduced and redistributed.
2. The depth of the glass was reduced from 59″ to 47″.
3. The crown was raised approximately 12″.
4. The fuel was changed from coke oven to natural gas.
5. A conventional low-pressure burner system was installed.

6. The batch mixer was changed from a "pugmill" type to the "tumbler" type.
7. The batch conveying mechanism was streamlined in order to minimize mechanical failures.
8. The batching system was made automatic, and suitable protection devices were installed.
9. Specific furnace sidewall block refractory types were changed.
10. Modifications were made in order to increase the available draft.
11. The ribbon width was increased from 52" to 103".

It is logical for one to ask, "Did subsequent furnace performance justify the cost of these modifications to the system?" We think it did. The average furnace output was increased from 136 tons per operating day per campaign to approximately 200 tons. In addition, ream was reduced from its "Number 1 Public Enemy" status to that of insignificance.

The purpose of this paper was not to imply that the glass manufactured at Ford Motor Company is either more or less homogeneous than that made by other manufacturers of flat glass. Our plate glass is still not completely free of non-homogeneous layers but we have made tremendous progress toward this end. Perfection still remains our goal.

High Temperature Alloys in the Glass Industry

(*Continued from page* 422)

Rockwell C scale, they are tough and can be made to have an extremely fine surface. Depths of cut should be larger than 0.005 inch and feeds should be of at least the same order. Specific instructions for the single point turning of Viscotherm 5 are given in Table III as a starting point.

The instructions for turning are for material hardnesses of the order of from R_C30 to R_C38. Innovations

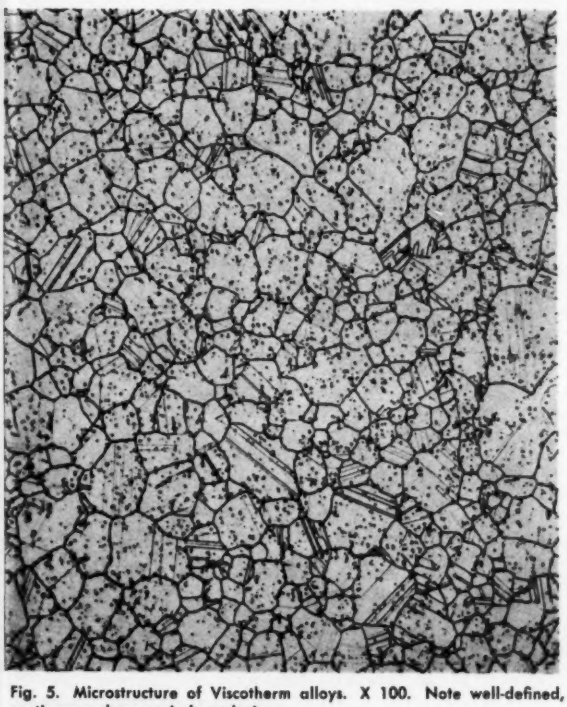


Fig. 5. Microstructure of Viscotherm alloys. X 100. Note well-defined, continuous, clean grain boundaries.

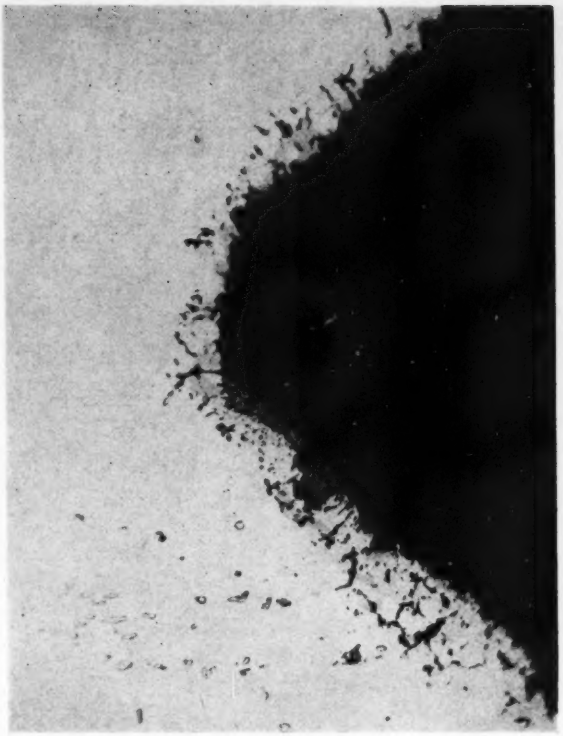


Fig. 6. Hard-refractory oxide layer formed on Viscotherm alloy protects it against corrosion and abrasion. White area is alloy; dark area is oxide layer. Note how layer follows surface formation. X 300.

Table III

SINGLE POINT TURNING OF VISCOTHERM 5

	Rough	Finish
Tool Material	Carboloy 883	Carboloy 999
Tool Geometry		
Back Rake	0	0
Side Rake	10	10
End Relief	10	10
Side Relief	10	10
End Cutting Edge Angle	5	5
Side Cutting Edge Angle	45	45
Nose Radius	.020"	.020"
Cutting Speed	70-80 sfm	90-100 sfm
Feed	.008-.012"/rev.	.005-.008"/rev.
Depth	No limit	.015-.025"
Coolant	Johnson TL-131	Johnson TL-131

such as cast cobalt tooling and cobalt high-speed tools may be tried later. Similar data on milling, drilling and low-stress grinding are available.

Viscotherm alloys are presently produced in the form of hot- and cold-rolled bar, forgings, sheet and strip. Development work is under way on alloys in the form of centerless-ground rod, coiled wire, and welding electrodes.

REFERENCES

1. "Announcing a New Family of Alloys," publication by Metals Division, Kelsey-Hayes Company, New Hartford, N. Y., 1959.
2. "Vacuum Induction Melting," F. N. Darmara, J. S. Huntington and E. S. Machlin, *J. Iron and Steel Institute*, V. *191*, pp. 266-275, March, 1959.
3. "Metal Data," 2nd ed., S. L. Hoyt, Reinhold Publishing Corp., 1952, p. 428.
4. "Precipitation from Solid Solution," American Society for Metals, Cleveland, Ohio, 1959, p. 421.

(Next month the author will discuss in detail some of the applications in which these alloys are now being used in glass manufacturing and will present ideas on how they can be used in other glass-making areas.)

Research Digest

(*Continued from page* 436)

tion phenomena are usually associated with slip along a crystal plane due to shear stress. In the case of isotropic glass, it has been suggested by Zachariasen that there is a short range order in glass structure. He points out that glass can form a network with energy content comparable with a corresponding crystal structure. The long-range disorder in glass would probably prevent the formation of pronounced slip planes through the structure. The etching results generally indicate that the flaws in glass are produced by lateral tension stress (during cooling, mechanical shock, etc.) and not by shear forces. We may be at the point where it is difficult to differentiate between a crack and a dislocation. Detailed experiments are now being started in an attempt to resolve this dilemma.

Minute flaw patterns were developed and studied in soda-lime-silica glasses by using a new chemical etching technique. This technique utilizes the slow action of dissociated sodium fluoride on glass. Characteristics of these selectively etched flaws indicate that they are much narrower and react differently to the chemical etching than ordinary cracks and fissures in glass. An etched sample generally disclosed a greater rate of attack in the flaw regions than on the surrounding surface.

Flaws were formed at the tips of aged cracks which could be detected in the same location on opposite halves of the cleavage surfaces. This effect was analogous to dislocation phenomena occurring at the tips of slow moving fissures in crystals. The formation of this crack tip flaw was also believed to account for strength increase effects observed in glass containing deep fractures.

Various other facts which were discovered with this method are:

(1) A repeating oriented type of flaw pattern was observed in glass containers. Weathering effects could also be readily detected.
(2) Oriented flaws were found on sheet glass in the direction of "draw."
(3) Flaws are formed when the glass is well above the "strain point" temperature and the number increases with increasing residual stress. The flaws are also influenced by internal homogeneity.
(4) The impact strength of glass containers was found to be inversely related to the logarithm of the average number of flaws.
(5) Flaw patterns may be formed by localized stresses which are suggestive of shock wave phenomena.
(6) The flaws in glass fibers decreased rapidly with decreasing fiber diameter. Below a diameter of about 10^{-2} mm. the probability of finding a flaw is exceedingly small.

The points listed above indicate that this technique may be very useful as a diagnostic tool in glass breakage studies.

Lead Sulphide Films

(*Continued from page* 425)

No. 96,906. P. Guillery. Lead sulphide photo-elements, Part XV, March 1949, 9 pages.

No. 101,399. Mirror Manufacture, 11 pages, September 1950.

Amerikanov, K. I.
Jour. Ex. Theo. Phys. Vol. 14, p. 187, 1944; *Chem. Abst.* Vol. 39, p. 1581, 1945.

Anderson, N. C.
U. S. Pat. #2,659,682 Nov. 17, 1953.

Anonymous
P. B. Report #101,399, 1950; *Chem. Eng. News*, Vol. 17, p. 844, 1948.

Baird Associates, Inc., Cambridge, 33, Mass.

Baker, V. B.
Industrial Photoelectric Control, *Industrial Electronics Reference Book*, p. 187, p. 632.

Banbury, P. C.; Gebbie, & Hogart, C. A.
Chem. Abst. Vol. 49, p. 7422, 1955.

Bauer, K.
Ann. Phys. Vol. 30, p. 433, 1937; Vol. 38, p. 84, 1940. *Chem. Abst.* Vol. 32, p. 1536, 1938; Vol. 35, p. 947, 1941. Beutel, E. & Kutzelnigg. A. *Monatsch.* Vol. 58, p. 295, 1931; Vol. 62, p. 252, 1933; *Chem. Abst.* Vol. 26, p. 5502, 1932; Vol. 27, p. 4462, 1933.

Blackwell, D. E.; Simpson, O.; & Sutherland, G.
Nature, Vol. 160, p. 793, 1947.

Bruckman, G.
Kolloid. Zeit. Vol. 65, p. 1, 148, 1933; *Chem. Abst.* Vol. 28, p. 389, 1241, 1934.

Case Research Laboratories, Auburn, New York.

Cashman, R. J.
O. S. R. D. Report #5998, Oct. 31, 1945; *Jour. Opt. Soc. America*, Vol. 36, p. 356A. 1946; *Photodetectors For Ultra Violet, Visible & Infra Red Radiation*, Vol. 2, 1946; *Nature*, Vol. 161, p. 281, 1948; U. S. Pat. #2,448,516 Sept. 7, 1948; U. S. Pat. #2,448,517 Sept. 7, 1948; U. S. Pat. #2,448,518 Sept. 7, 1948; *Chem. Abst.* Vol. 43, p. 500, 1949.

Colbert, G. W. & Colbert, W. S.
U. S. Pat. #1,603,936 Oct. 19, 1926; U. S. Pat. #1,647,857 Nov. 1, 1927; U. S. Pat. #1,662,564 Mar. 13, 1928; U. S. Pat. #1,662,565 Mar. 13, 1928.

Colbert, W. H. & Morgan, W. L.
U. S. Pat. #2,387,745 Oct. 30, 1945; U. S. Pat. #2,394,533 Feb. 12, 1946; U. S. Pat. #2,411,955 Dec. 3, 1946; U. S. Pat. #2,418,335 Apr. 1, 1947; U. S. Pat. #2,430,452 Nov. 11, 1947; U. S. Pat. #2,519,545 Aug. 22, 1950; U. S. Pat. #2,519,546 Aug. 22, 1950; U. S. Pat. #2,519,547 Aug. 22, 1950; *Chem. Abst.* Vol. 41, p. 844, 3556, 1947; *Chem. Abst.* Vol. 42, p. 1105, 1948.

Colebrook, F. M.
Exper Wire. & Wire. Eng. Vol. 2, p. 330, 394, 459, 1925.

Colbert, W. H.; Weinrich, A. R. & Morgan, W. L.
U. S. Pat. #2,482,054 Sept. 13, 1949

Continental Electric Co., Geneva, Illinois.

Croatto, V. C.
Gazz. Chim. Italy, Vol. 79, p. 458, 1949; *Chem. Abst.* Vol. 43, p. 8340, 1949.

Colbert, G. W.; Morgan, W. L. & Weinrich. U. S. Pat. #2,508,858 May 23, 1950; *Chem. Abst.* Vol. 44, p. 7508, 1950.

Davidenko, V. A.
Bull. Acad. Sci. Vol. 5, p. 546, 1941; *Chem. Abst.* Vol. 38, p. 4171, 1944.

DeVry Company, Chicago, Illinois.

Dunaev, Y. A. & Maslavkovets, Y. P.
Zhur. Eksptl. Theiret. i. Fiz. Vol. 7, p. 901, 1947; *Chem. Abst.* Vol. 43, p. 4532, 1949.

Dusault, H. A.
Internat. Project. Vol. 23, p. 11, 1948.

Eastman Kodak Co., Rochester, New York.

Eckerlin, H.
U. S. Pat. #2,306,869 Dec. 29, 1942.

Excel Movie Prod. Co., Chicago, Illinois.

Fireye Corporation, Boston, Mass.

Fischer, P.
Zeit. Electrochem. Vol. 33, p. 571, 1927; *Chem. Abst.* Vol. 20, p. 2276, 1926; *Chem. Abst.* Vol. 21, p. ?????.....

Fuji, K.
Proc. World Eng. Cong. Tokyo, Vol. 22, p. 331, 1931; *Chem. Abst.* Vol. 25, p. 5604, 1931.

Gaddens, B. B.
P. B. Report 96,9002.

Gardner, I. C. & Case, F. A.
Bureau of Standards Circular #389, Jan. 6, 1931.

Guillery, P.
P. B. Report 96,905 March 1949, XV".

Gorilch, P.
Zeit. fur Naturforsh. Vol. 2a, p. 47, 1947.

Hansell, C. W.
Miscell. Develop. In German Sci. & Indust. Report #C-60, of the Joint Intelligence, and Report #68, June 1945.

Hauser, O. & Biesalsky, E.
Chem. Zeit. Vol. 34, p. 1079, 1910; Vol. 5, p. 437, 1911.

Hawksley, C. P.
Process Engineers Monthly, Vol. 56, p. 273, 1949.

Heidenhain, J.
U. S. Pat. #1,877,310 Sept. 13, 1932; Brit. Pat. #327,068 Mar. 27, 1930; Brit. Pat. #351,626 July 2, 1931; Brit. Pat. #442,473 Feb. 10, 1936; *Chem. Abst.* Vol. 24, p. 1809, 2073, 4722, 1930; Vol. 25, p. 3581, 1931; Vol. 26, p. 883, 1932; Vol. 27, p. 33, 1837, 1933; Vol. 30, p. 4776, 1936.

Heineck, F.
Naturwissen. Vol. 20, p. 365, 1932; *Phys. Zeit.* Vol. 35, p. 113, 1934.

Henderson, T.
Brit. Pat. #464,105 April 9, 1937.

Hinterberger, H.
Zeit. Phys. Vol. 119, p. 1, 1942; *Naturwissen*, Vol. 29, p. 79, 1941; *Office of Tech. Services*, P. B. Report #2211 and #3536; *Chem. Abst.* Vol. 35, p. 7282, 1941; Vol. 36, p. 6391, 1942.

Huxford, W. S., & Platt, J. R.
Jour. Opt. Soc. America, Vol. 38, p. 253, 1948.

James, H. M.
Science, Vol. 110, p. 254, 1949.

Joffe, A. V.
Corupt. Rend. Vol. U.R.S.S. Vol. 27, p. 547, 1947; *Chem. Abst.* Vol. 34, p. 7687, 1940.

Kempf, R.
Glasshutte, Vol. 72, p. 269, 1942; *Chem. Zentrl.* Vol. 1, p. 2331, 1943; *Chem. Abst.* Vol. 38, p. 4393, 1944

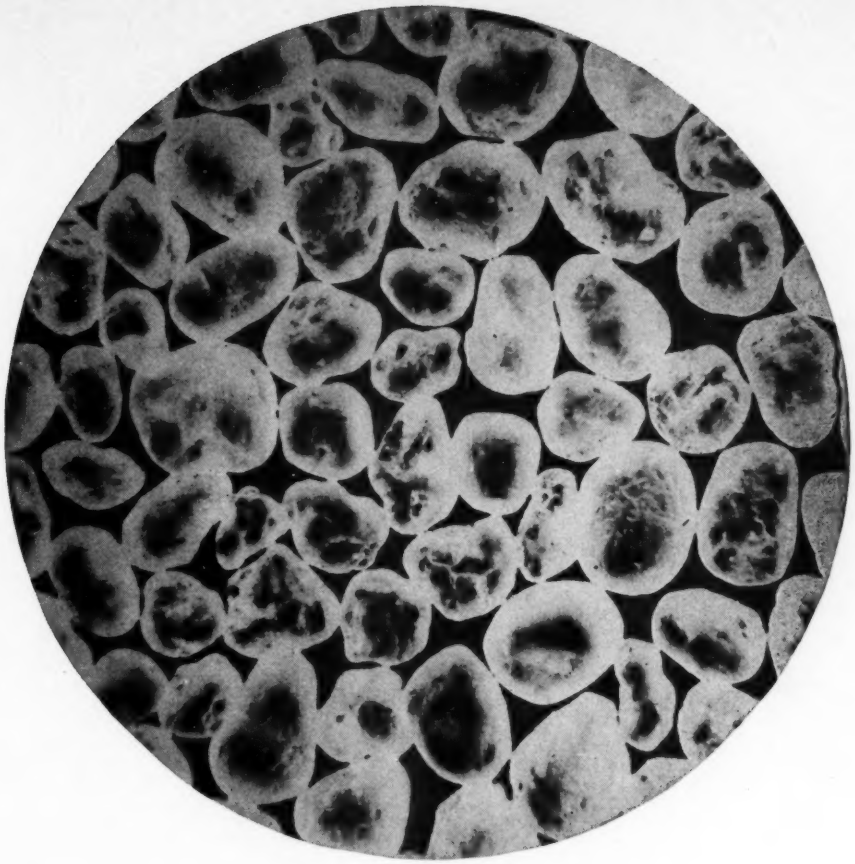
Kichinski, E.
Chem. & Ind. Vol. 28, p. 54, 1948; *Chem. Abst.* Vol. 42, p. 2876, 1948.

Kulper, C.
Astro. Phys. Soc. Vol. 106, p. 243, 1947.

Kulper, C. Wilson, W. R. & Cashman, R. P.
Astro. Jour. Vol. 106, p. 243, 1947.

Kutscher, E.
P. B. Report #96,904.

(*Continued on page* 448)



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(*Continued from page 446*)

Lange, B.
Naturwissen. Vol. 29, p. 525, 1931; *Phys. Zeit.* Vol. 31, p. 139, 1930; *Chem. Abst.* Vol. 24, p. 1797, 5083, 1930
Lebedev, P. P.
Zeit. Electrochem. Vol. 18, p. 891, 1912; *Chem. Abst.* Vol. 7, p. 307, 1913.
Lee, R. W.
Jour. Soc. Mot. Pict. Eng. Vol. 53, p. 691, 1949.
Lee, E. & Parker, R. C.
Nature, Vol. 158, p. 518, 1946.
Luke, H.
Phys. Zeit. Vol. 28, p. 213, 1927.
Meltsner, M.
Jour. Amer. Chem. Soc. Vol. 57, p. 2554, 1935; *Chem. Abst.* Vol. 30, p. 1741.
Mercadier, E. J.
U. S. Pat. #420,884, 1880.
Morton, M. C.
Trans. Faraday Soc. Vol. 43, p. 194, 1947.
Moss, T. S.
Nature, Vol. 159, p. 476, 1947; Vol. 161, p. 766, 1948.
Moss, T. S., & Cashman, R. P.
Nature, Vol. 161, p. 244, 1948.
Osborn, W. E.
Electronics, Oct. 1, p. 155, 1955.
Paksuer, S.
Electronics, May, 1949.
Peacock, Wm.
U. S. Pat. #1,988,663 Jan. 22, 1935; *Chem. Abst.* Vol. 29, p. 1542, 1935.
Pessel, L.
U. S. Pat. #2,689,191 Sept. 14, 1954.
Pick, H.
Zeit. Physik. Vol. 126, p. 12, 1949; *Chem. Abst.* Vol. 43, p. 883, 1949; *Office of Tech. Serv.* PB-Report #78,621.
Putseiko, E. K.
Doklady Akad. Nauk. S. S. S. R. Vol. 67, p. 1009, 1949; *Chem. Abst.* Vol. 43, p. 8895, 1949.
Revere Co., Boston, Mass.
Reynolds, J. E.
Jour. Chem. Soc. Vol. 22, p. 1, 1869; Vol. 45, p. 162, 1884; Vol. 59, p. 383, 1891; Vol. 83, p. 83, 1903; Brit. Pat. #1112 Mar. 15, 1880.
Reynolds, J. E. & Grubb, G. R.; Brit. Pat. #4420, Feb. 6, 1902; German Pat. #144,582 Nov. 3, 1901; German Pat. #148,893 Feb. 12, 1902; U. S. Pat. #722,901 Mar. 17, 1903.
Schade, W.
Zeit. Phys. Vol. 36, p. 499, 1935.
Schlede, A. & Buggish, H.
Zeit. Anorg. Chem. Vol. 16, p. 85, 1927.
Schwarz, E.
Nature, Vol. 162, p. 614, 1948; *Chem. Abst.* Vol. 43, p. 2858, 1949.
Siemens, S. & Demberg, W.
Zeit. Phys. Vol. 67, p. 375, 1931; *Chem. Abst.* Vol. 25, p. 4184, 1931.
Sharples Chemicals Co., Pittsburgh, Pa.
Snelling, W. O.
U. S. Pat. #1,585,431 May 18, 1926; *Chem. Abst.* Vol. 20, p. 2127, 1926.
Sommer, G.
Ultraviolet, etc. p. 242.
Sosnowski, L.; Starkiewicz, J., & Simpson, O.
Nature, Vol. 158, p. 28, 1946; Vol. 159, p. 818, 1947.
Sponable, E. I.
Jour. Soc. Mot. Pict. Eng. Vol. 49, p. 347, 1947.
Starkiewicz, J.
Jour. Op. Soc. Amer., Vol. 38, p. 481, 1948.
Simpson, O. & Sutherland, G. G.
Science, Vol. 115, p. 1, 1952.
Simpson, O.
Nature, Vol. 160, p. 791, 1947.
Sosnowski, L.
Phys. Rev. Vol. 72, p. 641, 1947.
Tied, F. & Bruckman, G.
Zeit. Phys. Vol. 80, p. 382, 1933; *Chem. Abst.* Vol. 27, p. 2090, 1933.
Trev, F.
Naturwissen. Vol. 18, p. 1099, 1930; *Zeit. Phys.* Vol. 26, p. 849, 1925; *Chem. Abst.* Vol. 20, p. 1156, 1926; Vol. 25, p. 1717, 1931.
Tubandt, C.; & Haedicke, M.
Zeit. Anorg. Allgem. Chem. Vol. 160, p. 297, 1927; *Chem. Abst.* Vol. 21, p. 1748, 1927.
Vrede, J.
Zeit. Phys. Vol. 31, p. 323, 1930; *Chem. Abst.* Vol. 24, p. 3430, 1930.
Walther, R.
Jour. Prakt. Chem. Vol. 54, p. 511, 1896.
Wein, Samuel
Glass Industry, Vol. 40, p. 244, 304, 1959.
Wilman, H.
Proc. Phys. Soc. Vol. 60, p. 117, 1948; *Chem. Abst.* Vol. 43, p. 3720, 1949.
Wilson, W. R.
Phys. Rev. Vol. 72, p. 156, 1947.
Zhuse, V. P. & Ryvkin, S. M.
Doklady Akad. Nauk. S. S. S. R. Vol. 62, p. 55, 1948; *Chem. Abst.* Vol. 43, p. 482, 1949.
Zworykin, V. K. & Wilson, W. R.
Photocells And Their Applications, p. 187.

Inventions and Inventors

(*Continued from page* 435)

high-refractive-index, glass elements, such as glass beads, fibers, flakes and thin plates. The glass elements of this invention have especially high-refractive indices, i.e., above 2.4 and up to approximately 2.51.

The unusual discovery of this invention is that trans-

How well do you know your glass?

HERE YOU SEE A:

- ☐ 1. Low-key photograph
- ☐ 2. Textured glass window
- ☐ 3. Fiberglas screen
- ☐ 4. Butterfly pressed in glass

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parent small glass elements possessing extraordinarily high-refractive-indices in combination with other required properties can be made from titanium dioxide and lead oxide alone. By using these two components and by keeping titanium dioxide within the range of 15 to 50 weight per cent and lead oxide within the range of 85 to 50 weight per cent, glass elements have been obtained having such high indices of refraction as above 2.4, and in addition, having the transparency and resistance to weathering required of small glass beads for highway signs and markers.

The following table illustrates the compositional analysis in weight per cent of glass elements made according to this invention.

Composition Number	TiO_2	PbO	Impurities	Refractive Index
1	15.	85		2.51
2	18.2	81	0.8 Al_2O_3	2.49
3	19.3	80.7		2.50
4	20	80		2.50
5	26.4	73.6		2.50
6	30	70		2.49
7	32.3	67.7		2.49
8	36	63.2	0.8 ZrO_2	2.48
9	37.5	62.5		2.49
10	40	60		2.49
11	41.8	58.2		2.49
12	48	52		2.48

There were 4 claims and the following references cited in this patent.

United States Patents

2,472,447, Kuan-Han Sun, June 7, 1949.

Other References

Page 150 (Fig. 404), *Phase Diagrams for Ceramists,* by Ernest M. Levin et al., published by the American Ceramic Society Inc. (1956).

Minnesota Mining & Mfg. Co., 153,066, Sept. 2, 1953 (Australian), 14 cols.

Refractory vitreous ceramic coating materials. Patent No. 2,829,062. Filed February 7, 1956. Issued April 1, 1958. No sheets of drawings; none reproduced. Assigned to United States of America by Dwight G. Bennett, Champaign, and William J. Plankenhorn.

This invention relates to refractory vitreous ceramic coating materials, and more particularly, relates to new coating compositions for use with stainless steel whereby protection against oxidation and corrosion is provided at elevated temperatures.

The frits suitable for use in preparing the ceramic coating materials consist of the following ingredients: Silicon dioxide (SiO_2), 25 to 35%; boron oxide (B_2O_3), 12 to 25%; strontium oxide (SrO), 15 to 25%; zinc oxide (ZnO), 4 to 6%; calcium oxide (CaO) 3 to 5%; cerium oxide (CeO_2), 4 to 6.5%; vanadium oxide (V_2O_5), 3 to 5%; and titanium dioxide (TiO_2), 10 to 20%.

The raw batch materials include quartz (SiO_2), boric acid (H_3BO_3), strontium carbonate ($SrCO_3$), zinc oxide (ZnO), calcium carbonate ($CaCO_3$), cerium oxide (CeO_2), vanadium pentoxide (V_2O_5), and titanium dioxide (TiO_2). (*Continued on next page*)

High Temperature Lubricants

FOR THE GLASS INDUSTRY

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It has now been discovered that a stable and non-toxic ceramic coating material particularly suitable for application over stainless steel surfaces may be obtained by utilizing these specially formulated frits of the borosilicate type which are alkali- and alumina-free. They show improved high temperature results against oxidation and corrosion at higher temperatures in the absence of chipping, flaking, or other forms of deterioration.

There were 4 claims and the following references cited in this patent.

United States Patents

Re. 22,011, Kinzie et al., Jan. 20, 1942; 1,938,691, Dougherty, Dec. 12, 1933; 2,352,425, Deyrup, June 27, 1944; 2,396,856, King, Mar. 19, 1946; 2,414,633, Bryant, Jan. 21, 1947; 2,475,470, Bennett et al., July 5, 1949; 2,588,250, Kopelman, Mar. 4, 1952; 2,733,158, Tiede, Nov. 7, 1956; and 2,753,271, Treptow, July 3, 1956.

Glass Wool and Fiber

Manufacture of foamed latex sponge reinforced with glass fibers. Patent No. 2,809,174. Filed October 26, 1953. Issued October 8, 1957. No drawings. Assigned to United States Rubber Company by Paul Dereniuk.

According to the invention advantages are obtained if the slurry of glass fibers in water containing a cationic surface-active agent is prepared as a three-phase system of water, solids and air having a wet density of 0.2 to 0.8 gram per cc. before being mixed with the latex or the foam. It is possible to utilize a slurry of glass fibers in water containing a non-ionic surface-active agent if it is similarly prepared as a three-phase system of water, solids and air having the same wet density.

A particular advantage of the present invention is that the three-phase system of water, solids and air in the case of glass fibers is more fluid than the two-phase system of water and fibers, and that the fluidity increases as the density of the aerated slurry decreases.

This is opposite to the case of the latex itself where the aeration or foaming of the latex decreases its fluidity considerably. This surprising increase in the fluidity of the fiber slurry with decreasing density greatly facilitates preparation of the fiber slurry and decreases the power necessary to mix the fibers with the water with the incorporation of increasing amounts of air. With high solids fiber content in the absence of air, pumping of the fiber slurry may not be practical since it acts more like a wet solid, whereas on inclusion of air such slurries become fluent.

Thus a second advantage is the ease of pumping and metering the fiber slurry. A third distinct advantage appears particularly when the aerated fiber slurry is mixed with the latex foam in that it is easier to mix the lower density fiber slurry with the low-density latex foam since the higher density slurry may have a tendency to drop down through the latex foam to the bottom of the mixing apparatus and make uniform mixing difficult.

There were 6 claims and the following references cited in this patent.

United States Patents

2,382,561, Gregory, Aug. 14, 1945; 2,432,971, Ruthman, et al., Dec. 16, 1947; 2,451,446, Parsons, Oct. 12, 1948; 2,498,785, Bennett, et al., Feb. 28, 1950; 2,542,364, Schenker, et al., Feb. 20, 1951; and 2,650,184, Biefeld, Aug. 25, 1953.

Foreign Patent

500,340, Canada, Mar. 2, 1954.

Other Reference

Bennett: Concise Chemical and Technical Dictionary. Copyright 1947; page 275.

Sheet and Plate Glass

Apparatus for grinding or polishing flat glass. Patent No. 2,833,090. Filed December 6, 1954. Issued May 6, 1958. No sheets of drawings; none reproduced. Assigned to Societe Anonyme des Manufactures des Glaces Produits Chimiques de St. Gobain, Chauny & Cirey by Robert Touvay.

This invention relates to apparatus for grinding or polishing flat glass, in particular apparatus for simultaneously surfacing (grinding or polishing) both faces of a horizontal ribbon of glass.

The apparatus is characterized by the coaxial pairs of tools being mounted in a structurally continuous frame in the shape of a closed flattened loop, forming a rigid ring-like unit through which the ribbon is advanced. The frame unit so constructed absorbs the reactions to which the tools are subjected and the vibrations which may be developed.

Preferably the ring-like unit is constituted by two similarly dimensioned upper and lower components, each comprising a horizontal beam and vertical column elements at each end of the beam, which components are bolted together at the junction of the column elements to form the continuous ring-like structure.

By uniting the two components of the continuous ring-like unit to form an integral whole, the upper and lower tools of the apparatus are virtually mounted in a single continuous unit structure, which arrangement permits an absorbtion of the reactions to which the tools are subjected and of the vibrations which may be developed as a result of synchronized rotation of the co-axial tools, and by the absorption of the reactions and vibrations a more regular and uniform work from the tools can be achieved.

A ring-like unit structure constructed according to the present invention may comprise lateral supports which ride on bearing surfaces so that the unit with the co-axial surfacing tools mounted in it may be bodily moved transversely of the ribbon, the beam portions of the unit having a length such that a bodily movement of the unit is permitted which enables the co-axial tools to be disposed at the side of the ribbon of glass to allow access to the surfacing elements of the tools.

In such form of unit structure the beam in the lower component preferably carries a support for the ribbon, the support being constituted by a base plate fixed on the beam and a plurality of castors individually mounted on the base plate, the arrangement being such that when the unit is displaced transversely of the ribbon the base plate and the associated castors constitute a temporary support for the ribbon.

There was 1 claim and the following references cited in this patent. (*Continued on page* 452)

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(*Continued from page* 450)

United States Patents

393,051, Aiken, Nov. 20, 1888; 2,176,481, Waldron et al., Oct. 17, 1939; 2,285,318, Waldron, June 2, 1942; 2,355,174, Nye, Aug. 8, 1944; 2,508,863, Labby et al., May 23, 1950; 2,646,655, Laverdisse, July 28, 1953; and 2,664,711, Howlett, Jan. 5, 1954.

Foreign Patents

675,830, Great Britain, July 16, 1952.

Miscellaneous Processes

Decorating glass with organic ink. Patent No. 2,821,486. Filed August 30, 1954. Issued January 28, 1958. No sheets of drawings; none reproduced. Assigned to Owens-Illinois Glass Company by Anna S. Naff and Robert M. Smith.

The use of organic inks or color materials offers substantial advantages particularly as the curing may be effected at comparatively low temperatures and in a short time of treatment. A serious objection which has been found in the use of such organic materials relates their inability to withstand the action of moisture for any length of time.

In practicing the present invention epoxy resins are used as the base for making the inks for decorating glassware or the like. An epoxy resin is used because it is more adherent to glass and forms a harder and tougher film than other resin or organic material.

Examples of ink formulations which have been found to give good results are as follows:

	Parts
Epoxy resin (Epon 828)	10
Pigment (Titanox RA-50)	10
Citric Acid	2.5
Carbitol (diethylene glycol monoethyl ether)	3.75
Silicone (GE 81392)	0.26

The resin is an epoxy hydroxy polyether resin. The term "Epon" in the above example is the trade name for epoxy resins supplied by the Shell Chemical Corporation.

The "Epon 828" is an epoxy resin having a viscosity (Gardner-Holdt) of Z_5—Z_6, an epoxide equivalent (grams of resins containing 1 gram equivalent of epoxide) of 190-210, and a melting point of 8°C. to 12°C. Such resins may be obtained on the open market as these are a number of producers supplying such resins.

The pigment known by the trade name Titanox is a titanium dioxide and is supplied by the Titanium Pigment Corporation, a division of the National Lead Company. The Carbitol is a diethylene glycol monoethyl ether supplied under this trade name by the Carbide and Carbon Chemicals Corporation. It is used in the above formulation to dissolve the citric acid. The silicone (GE 81392) is a product supplied by the General Electric

(*Continued on page* 454)

HOT COLOR PRINTING

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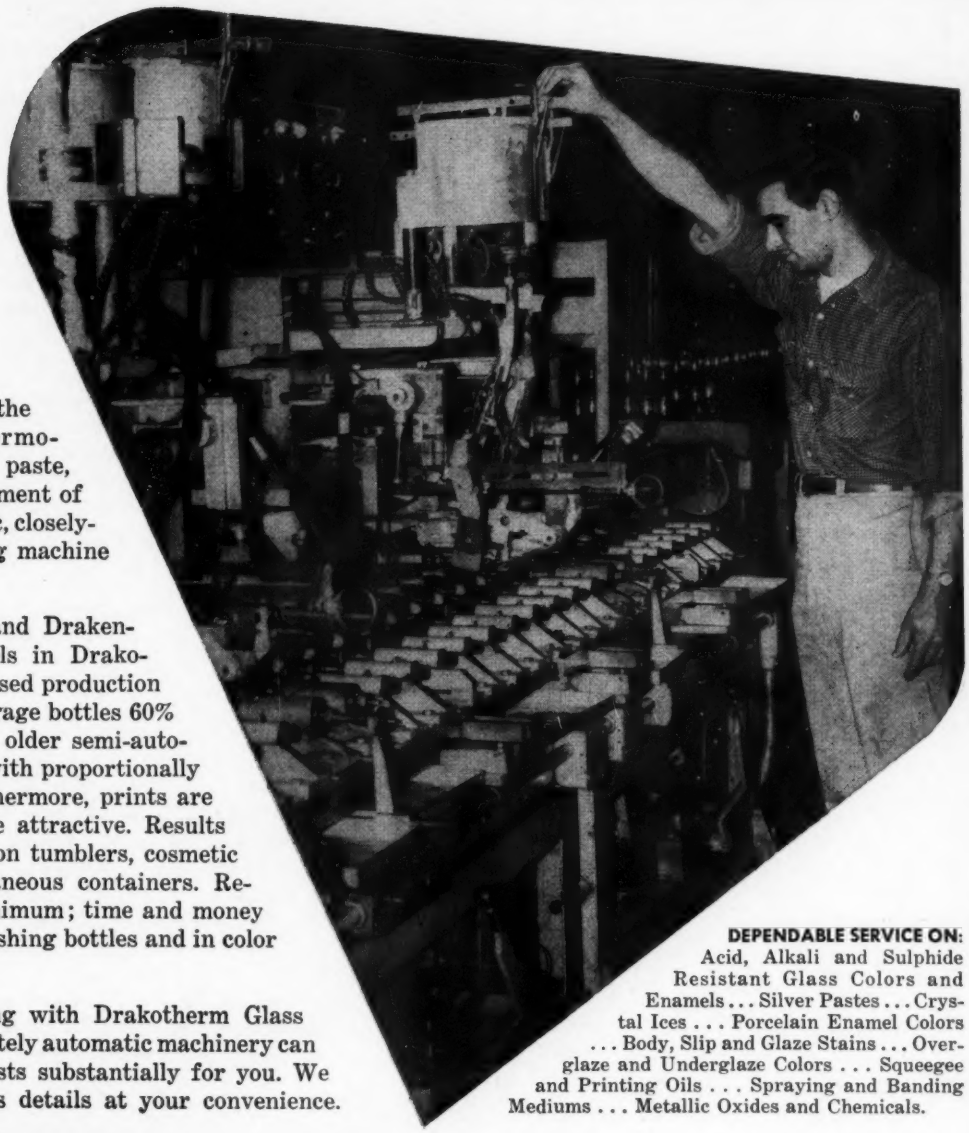

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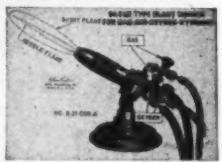

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FOR THE GLASS INDUSTRY

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(*Continued from page* 452)

Company. It serves as a leveling agent.

The hardness of printed films may be determined by means of a graduated series of drawing pencils. Pencils with a lead hardness of from 1 H to 9 H are used to scratch the ink film. The ink is given a hardness rating equivalent to the hardest pencil which will not scratch the film. The ink is applied by means of a silk screen or a doctor blade.

There were 8 claims and the following references.

United States Patents

2,121,680, Arvin, June 21, 1938; 2,324,483, Castan, July 20, 1943; and 2,569,920, Buck et al., Oct. 2, 1951.

Errata

Warminster Fiberglas Co. was misspelled on page 367 of the July issue.

The book, "Rare Metals Handbook," reviewed on page 382, July issue, is edited by Clifford A. Hampel.

Rubidium in Lead and Barium Glasses

(*Continued from page* 417)

means that these larger alkali ions can be used as the dominating or controlling factor to control expansion.

The following abstract[6] taken from their work indicates that the Russians have obtained similar results with cesium silicate glasses. The details of the abstract follow:

> Results are presented which indicate that Cs_2O increases the thermal expansion of silicate glasses to a much greater extent than Li_2O, Na_2O, or K_2O. The study was conducted on fifty 3-component glasses from the system Cs_2O-CaO-SiO_2 contained Cs_2O from 10 to 35 mole %; 4-component glasses from the system Cs_2O-Na_2O (or K_2O, or Li_2O)-Al_2O_3-SiO_2 contained Cs_2O from 0.44 to 5.7 mole %. The partial characteristic, x Cs_2O, of the thermal expansion of Cs_2O was calculated by the formula, x Cs_2O x 10^{-7} = 530 − 5 (a-20), where a = mole % of Cs_2O in the glass. At the concn. of Cs_2O 20 mole %, the value x Cs_2O is constant, equal to 530 x 10^{-7}. It is the greatest value now known for the oxides used in glass manufacturing (x Li_2O, x Na_2O, x K_2O = 270, 395, and 465 x 10^{-7}, respectively). The use of Cs_2O is recommended for manufacturing glasses with a high coefficient of thermal expansion.

Another advantage that has been found for this type of glass is that the color of the rubidium glasses is considerably better than the corresponding potash glasses. This factor is highly important for high lead optical flints, because they are prone to develop amber or yellow colorations. Still another advantage of rubidium has been that there is apparently less attack on platinum with these glasses than with the corresponding soda or potash glasses.

Table VIII (page 417)—Physical Properties of Rb_2O-BaO-SiO_2 Glasses—indicates correlation of the physical properties with the per cent oxide composition of the various members.

The results of the density study indicate that these barium glasses are a little lower in density than the corresponding rubidium-lead glasses. This difference is to be expected inasmuch as barium possesses a lower atomic weight than lead. The same general trend was noted with the index of refraction. The Littleton softening point, on the other hand, indicated that the barium glasses are considerably more refractory than the corresponding lead glasses, and again this is to be expected because barium compounds in general are much more refractory than lead compounds.

The coefficients of expansion of the rubidium-barium glasses are quite interesting, and in order to compare them with the corresponding potash-barium glasses, the following calculations were made. These calculations show the difference in coefficient of expansion, α, of the rubidium glasses as determined and the corresponding potash glasses as calculated from the factors of Winkelmann and Schott.[5]

These results are similar to the rubidium-lead series and indicate a slight increase of the coefficient of expansion through the use of Rb_2O. However, this increase in the coefficient of expansion with barium glasses was not as pronounced as it was in the lead glasses. This

characteristic may be of definite interest to producers of barium optical glasses and barium flint glasses. The importance of using pure alkali carbonates is also evident if specific properties are to be desired and controlled.

Discussion of Results

A. Lead Glasses

The field of good glasses appeared to exist in the center of the diagram. The compositions showing glass possibilities were as follows. These glasses all showed varying characteristics, but it was apparent from the fusion study that commercial glasses may be possible from these compositions.

COMPOSITION OF GLASSES

Point #	Weight %			Mole %		
Member	Rb_2O	PbO	SiO_2	Rb_2O	PbO	SiO_2
17	40.0	10.0	50.0	19.6	4.1	76.3
18	30.0	20.0	50.0	14.8	8.2	77.0
19	20.0	30.0	50.0	10.0	12.5	77.5
20	10.0	40.0	50.0	5.0	16.8	78.2
23	50.0	10.0	40.0	27.3	4.6	68.1
24	40.0	20.0	40.0	22.0	9.3	68.7
25	30.0	30.0	40.0	16.6	14.0	69.4
26	20.0	40.0	40.0	11.2	18.8	10.0
27	10.0	50.0	40.0	5.6	23.7	70.7
30	60.0	10.0	30.0	37.1	5.2	57.7
31	50.0	20.0	30.0	31.2	10.5	58.3
32	40.0	30.0	30.0	25.2	15.9	58.9
33	30.0	40.0	30.0	19.1	21.3	59.6
34	20.0	50.0	30.0	12.8	27.0	60.2
35	10.0	60.0	30.0	6.5	32.7	60.8
41	40.0	40.0	20.0	29.5	24.7	45.8
42	30.0	50.0	20.0	22.3	31.3	46.5
43	20.0	60.0	20.0	15.1	37.9	47.0

The best glasses, which could be rated excellent in most cases, were as follows:

COMPOSITION OF GLASSES

Point #	Weight %			Mole %		
Member	Rb_2O	PbO	SiO_2	Rb_2O	PbO	SiO_2
24	40.0	20.0	40.0	22.0	9.3	68.7
25	30.0	30.0	40.0	16.6	14.0	69.4
26	20.0	40.0	40.0	11.2	18.8	70.0
27	10.0	50.0	40.0	5.6	23.7	70.7
33	30.0	40.0	30.0	19.1	21.3	59.6
34	20.0	50.0	30.0	12.8	27.0	60.2
43	20.0	60.0	20.0	15.1	37.9	47.0

It is significant to note that these glasses are generally high in Rb_2O. The better glasses contained from 10 to 40% Rb_2O, 20 to 60% PbO, and 20 to 40% SiO_2. The following glasses were quite good and showed

COMPOSITION OF GLASSES

Point #	Weight %			Mole %		
Member	Rb_2O	PbO	SiO_2	Rb_2O	PbO	SiO_2
17	40.0	10.0	50.0	19.6	4.1	76.3
18	30.0	20.0	50.0	14.8	8.2	77.0
19	20.0	30.0	50.0	10.0	12.5	77.5
20	10.0	40.0	50.0	5.0	16.8	78.2
23	50.0	10.0	40.0	27.3	4.6	68.1
24	40.0	20.0	40.0	22.0	9.3	68.7

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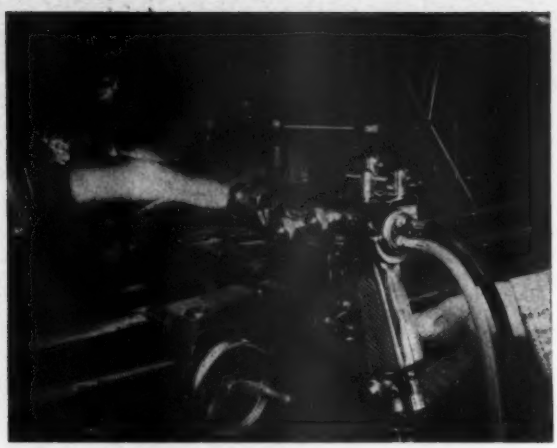

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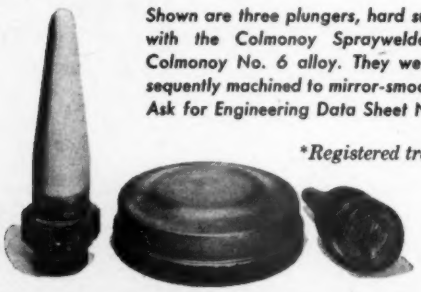

Shown are three plungers, hard surfaced with the Colmonoy Spraywelder and Colmonoy No. 6 alloy. They were subsequently machined to mirror-smoothness. Ask for Engineering Data Sheet No. 34.

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promise, but apparently are quite refractory; that is, a high temperature (probably greater than 2700°F.) would be needed to melt them properly.

Beyond the areas of good glasses the limiting factors were as follows:

1. Too high SiO_2 (generally greater than 50 per cent, weight per cent) produces considerable refractoriness.
2. Too high Rb_2O (generally greater than 40 per cent, weight percent) produces poor durability.
3. Too high PbO (generally greater than 60 per cent, weight per cent) produces devitrification and melting difficulties.

The outstanding characteristics of Rb_2O with this type of glass are (a) it contributes a high coefficient of expansion, (b) high viscosity, (c) less tendency to devitrify, and (d) good durability. Rubidium oxide appears to aid very definitely the glass forming characteristics of the mixtures and, therefore, makes possible glasses high in alkali.

B. Barium Glasses

The field of good glasses appeared to exist close to the center of the diagram and yet toward the Rb_2O-SiO_2 two-component system.

The compositions showing the best glass possibilities were as follows:

COMPOSITION OF GLASSES

Point #	Weight %			Mole %		
Member	Rb_2O	BaO	SiO_2	Rb_2O	BaO	SiO_2
17	40.0	10.0	50.0	19.3	5.8	74.9
18	30.0	20.0	50.0	14.2	11.7	74.1
23	50.0	10.0	40.0	26.7	6.5	66.8
24	40.0	20.0	40.0	21.2	12.9	65.9
25	30.0	30.0	40.0	15.6	19.2	65.2
26	20.0	40.0	40.0	10.3	25.3	64.4
27	10.0	50.0	40.0	5.1	31.2	63.7
32	40.0	30.0	30.0	23.6	21.5	54.9
33	30.0	40.0	30.0	17.4	28.3	54.3
34	20.0	50.0	30.0	11.5	35.0	53.5

The better glasses in this system were confined roughly to the following composition ranges:

SiO_2	30-55 per cent
BaO	10-50 per cent
Rb_2O	10-50 per cent

Generally speaking, glasses higher than 50 per cent SiO_2 were too refractory to melt successfully. Glasses in excess of 50 per cent BaO showed considerable attack on the porcelain refractory crucibles and also produced other melting difficulties such as difficulty in fining. It would appear that those glasses containing 30 to 50 per cent Rb_2O are quite desirable; that is, a high alkali content was necessary to provide good melting conditions. It is significant that these high Rb_2O glasses are still quite durable. It is not recommended, however, that glasses be used in excess of 50 per cent Rb_2O. Another characteristic of these BaO glasses is that certain lemon-to-orange colorations were noted, most of which were quite attractive. It is not known from the present study

whether these colors are due to impurities or a combination of Rb_2O and BaO. It is also possible that these colors may be eliminated by the use of platinum melting.

The general conclusion drawn from this study is that Rb_2O appears to enhance and help glass formation. The addition of Rb_2O to BaO glasses appears to improve greatly the melting condition and to enhance the possibilities of this type of glass. However, a high percentage of Rb_2O is needed (30 to 50 per cent), and the important fact is that with the use of Rb_2O such high percentages are possible and still maintain stable glasses.

V. Advantages of Rubidium

The advantages of rubidium as an alkali in glass appear to be that glasses of higher alkali content are possible, which will be stable and reasonably durable. Rubidium also appears to raise the coefficient of expansion, and, therefore, smaller amounts of this material may be effective in controlling this physical property in glass. This type of alkali, on the other hand, appears to provide a more refractory glass with higher viscosity that may demand a higher melting temperature. The Littleton softening point appears also to be higher than corresponding soda or potash glasses with the result that possible higher working temperatures may be needed. No actual durability tests have been determined, but there is every evidence to indicate that these glasses possess good durability, especially in their resistance to atmospheric moisture. There was no evidence of dimming of the surface of the better glasses when exposed to normal atmospheric moisture for prolonged times. Glasses have been made containing 35 to 40 per cent (weight per cent) rubidium, which apparently possess very good resistance. It is believed that this research study indicates the possibilities of the enhancing and broadening of glass properties as influenced by the alkaline content, and rubidium, as well as cesium compounds, will broaden the use of alkaline materials in glass. No effort was made to study the effects of rubidium when used with other alkalies—such as lithium, sodium, potash, or cesium—but it is believed that mixtures of these materials may broaden still further the versatile characteristics of these alkalies.

VI. Suggestions for Future Work

It is believed that other fields of study should be investigated involving the use of rubidium in simple alkali-lime-silica systems as well as in an alkali-magnesia-silica series.

The use of alumina and titania is another important area of study, along with the utilization of rubidium as the sole source of alkali for borosilicate glasses. These borosilicate glasses have important chemical and industrial applications, and the use of rubidium may produce unusual electrical and dielectric properties as well as enhancing chemical resistance.

ACKNOWLEDGMENT

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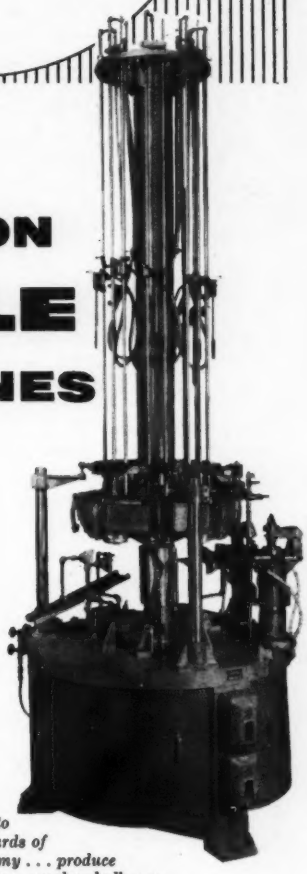

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